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SIMULATION PROCEDURES FOR INVESTIGATING THE EFFECTS OF VARIOUS SAMPLE SIZES ON ESTIMATES OF INCIDENTAL DOLPHIN MORTALITY

By

Christina H. Perrin, Bruce E. Wahlen and Elizabeth F. Edwards

ADMINISTRATIVE REPORT LJ-90-05

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CONTENTS

Page

INTRODUCTION..... 1

DATA SOURCES AND STRUCTURE..... 3

METHOD OF ESTIMATION..... 4

SIMULATION PROCEDURES..... 5

MONTHLY CUMULATIVE SIMULATION METHOD..... 5
NON-BACK-TO-BACK 50% COVERAGE SIMULATION METHOD..... 6
YEARLY MORTALITY ESTIMATION FOR SMALLER FLEETS..... 7

COMMANDS USED TO EXECUTE THE SIMULATION PROGRAMS..... 8

MONTHLY CUMULATIVE SIMULATION PROGRAMS..... 8
NON-BACK-TO-BACK 50% COVERAGE SIMULATION PROGRAMS..... 9
YEARLY MORTALITY ESTIMATION FOR SMALLER FLEETS..... 10

RANDOM SAMPLING PROCEDURES..... 11

SEQUENTIAL ALGORITHM..... 12
TREATMENT OF NON-INTEGER SAMPLE SIZES..... 12

STATISTICS REPORT FOR THE SIMULATION..... 13

SYMBOLS AND DEFINITIONS..... 14
EQUATIONS FOR THE MONTHLY CUMULATIVE MORTALITY ESTIMATES..... 14
SPECIAL NOTATION..... 15

COMPUTERS AND SOFTWARE USED..... 16

DISCUSSION..... 16

ACKNOWLEDGEMENTS..... 19

LITERATURE CITED..... 20

LIST OF TABLES

Table

1. Total and observed trips and days fished, 1979-88..... 3

2. Expected sample sizes and mean values of the actual sample sizes..... 13

3. Possible set classification scheme for mixed sets..... 18

LIST OF FIGURES

Figure — Page

1. Schematic diagram of data flow..... 21

2. Simulation diagram of cumulative monthly mortality estimates obtained by varying the percent coverage..... 22

3. Simulation diagram of yearly mortality estimates obtained by varying the fleet sizes and percent coverage..... 23

APPENDICES

Appendix 1. Format for "SAMPDAT" or "SAMP12" data files..... 24

Appendix 2. Format for the "MOSUMC" data file..... 24

Appendix 3. Format for the "BOAT" data file..... 25

Appendix 4. Format for the "VPOP" data file..... 25

Appendix 5. Monthly cumulative kill statistics on observed trips in 1987 (MOSUMC)..... 26

Appendix 6. Example of monthly cumulative mortality estimate report..... 27

Appendix 7. Example of smaller fleet simulation report..... 28

Appendix 8. Comparison of two kinds of CVs..... 29

Appendix 9. Format for the output file from VSEL1.FOR..... 30

Appendix 10. Program listings..... 31

VSEL0.FOR..... 31
VSEL1.FOR..... 33
VSEL2.FOR..... 36
PREKIL.FOR..... 43
PREKIL2.FOR..... 47
KILALL.FOR..... 50
SMPRR.FOR..... 57

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INTRODUCTION

The phenomenon of the tuna-dolphin association in the eastern tropical Pacific (ETP) has been used by purse seiners in locating and encircling much of their tuna catch since the late 1950s. Perrin (1969) described this "porpoise fishing" technique in detail and how the air-breathing dolphins get entangled, drowned, and killed in the process. An observer program started in 1968 by the National Marine Fisheries Service (NMFS) has been carried out routinely since 1971. In the program, scientific observers are placed on randomly selected U.S.-registered purse seiners to collect data on incidental mortality of dolphins (Lo et al., 1982). In 1979 the Inter-American Tropical Tuna Commission (IATTC) started a similar program for the international fleet, including U.S.-registered vessels (Allen and Goldsmith, 1981). Data thus collected have been used to calculate annual estimates of total incidental dolphin mortality and for related research. The estimates of the total number of dolphins killed each year are used as a basis for management by the NMFS (Lo and Smith, 1986).

Sample coverage (the number of vessels that carried observers) for the observer program is important in providing reliable mortality estimates. In the earlier years of the observer program, carrying an observer was voluntary and very few vessels were sampled, thus the data collected were insufficient to produce precise estimates of incidental dolphin mortality. Beginning in 1974, tunaboats were required by law to carry observers when requested, and the estimates for 1974 and thereafter are more precise for the U.S. fleet (Perrin et al., 1982 and Lo et al., 1982). The observer coverage has been between 25 to 55% (Table 1) of the total yearly trips made by the U.S. fleet, but in 1987, 124 of the total 134 trips made by the 34 U.S.-registered vessels fishing "on porpoise" were observed by either IATTC or NMFS scientific observers.

The data collected for 1987, a year with nearly 100% observer coverage, have been used to answer questions about the effects on the total mortality estimates of various sampling coverages, namely 25%, 33%, 50%, 75% and 96%, and for smaller fleets (Edwards and

Perrin, ms). We designed and produced three sets of computer simulation programs that provided simulated estimates of dolphin mortality and other values associated with the estimates as the basis for our analysis. Although we have used the kill-per-day as our estimator, the same programs and the 1987 data could be used to simulate total kills with different estimators, i.e., kill-per-ton and kill-per-set. These programs could also be used with data collected from other years.

The objective of this document is to describe the simulation procedures, particularly with the following specific purposes:

1. To illustrate the program and data flows (Figures 1, 2, 3) for each of the three simulations, so that the users of these computer programs know which ones to execute in order to achieve a specific type of estimate (annual estimates for a smaller fleet or monthly cumulative estimates for the U.S. fleet; samples (trips) taken completely randomly or with the "non-back-to-back" method).

2. To describe where the databases are located and what data files to use for producing specific simulated kill estimates. The Data Sources and Structure section shows how to format input data files to make the programs execute properly when using data from other years.

3. To document the selected method and options in computing the kill estimates, i.e. Cochran's ratio estimation techniques (Cochran, 1977). Detailed equations used in these simulations are extracted from Cochran and listed in the Method of Estimation section.

4. To describe the sampling methods, which are the nucleus of the simulations, and to state algorithms adopted in association with given computational methods.

5. To present users example output reports from each of the three simulations (Appendices 6 and 7) and show how statistics are generated by including the detailed equations used.

6. To alert users to the kinds of problems we have encountered during our simulations and to emphasize the need for caution in the areas of data nature, floating-point computation, and programming techniques. Since the need for new and improved methods and algorithms is never-ending, users of these simulation programs may form a new set of computer simulation programs by modifying or specializing these existing programs and algorithms.

The authors assume that the users of these computer programs have sufficient background in statistical methods and theory, especially the ratio estimation techniques discussed in Chapters 3 and 6 of Cochran (1977); have mathematical training in numerical analysis; and are familiar with the FORTRAN computer-programming language. The FORTRAN computer programs codes are listed as

Appendices and are available upon request by means of IBM PC formatted floppy diskette or magnetic tape. The Computers and Software Used section describes the hardware used in developing these programs. We hope this information and the source listings will give the user a base for translating the codes to another machine-compatible form if so desired and for giving us suggestions to improve efficiency or to correct errors.

Table 1. Total and observed trips and days fished, 1979-88[1].

	Trips			Days		
Year	Total	Obs	%	Total	Obs	%
79	269	114	42	20616	8947	43
80	259	104	40	18504	7822	42
81	235	99	42	18491	7434	40
82	215	85	40	17392	6966	40
83	150	47	31	10175	3115	31
84	106	30	28	6176	1789	29
85	110	48	44	6464	3025	47
86	101	42	42	4886	2174	44
87	134	124	93	8187	7595	93
88	147	81	55	7882	4173	53

DATA SOURCES AND STRUCTURE

Data collected in the observer program are stored and maintained in various databases. For this simulation, the Mammal Sighting database, the Mammal Effort database, the Set Log database and the Vessel Activity database for 1987 have been used to extract the needed information. The same type of information has also been extracted from observer databases that are maintained separately by the IATTC: Daily Activity database, Mammal Sighting database, Set Log database, and Kill database. The extracted information is combined to create a file named "FDAYS87.DAT", which contains a record for each day spent at sea for each IATTC- or NMFS-observed trip. Each record contains the cruise number, leg number, date, position, total number of dolphins killed and their species/stock composition, total tuna caught and total yellowfin tuna caught during the day. The dolphin species/stock categories are offshore spotted, eastern spinner, whitebelly spinner, unidentified spinner, common dolphin, striped dolphin, and "others and unidentified".

Two data files derived from "FDAYS87.DAT" are used in the monthly cumulative mortality simulation: the "SAMPDAT" and the

[1] Statistics for 1979-1986 and 1988 are compiled by K. Wallace with information provided by Southwest Region. Statistics for 1987 are calculated from data used for this simulation.

"MOSUMC" data files. The "SAMPDAT" data file is stratified by month and by trip and has been used as the sample space from which the simulation drew its sample. The "MOSUMC" data file (Appendix 5) is stratified by month only and provides the population statistics. Both files contain cumulative statistics for all observed trips. The January cumulative statistics include totals accumulated from January 1 through the end of January, and February's statistics include figures from January 1 through the end of February, and so forth. Their data file formats are listed in Appendices 1 and 2.

The "SAMPDAT" data file comprises a cumulative summary record for each month of the year for each trip. Its structure is governed by the following rules: (1) Trips made during the year are re-coded in such a way that number 1 is the first trip that departed during the year, number 2 is the second trip,..., number 124 is the last trip. (2) Records are arranged in ascending order by their stratified month and re-coded trip number. Thus the first record indicates the mortality information collected on the first trip that left port for the month of January.

Three more data files "BOAT", "VPOP" and "SAMP12" (Figures 1 and 3) are derived from the files described above. The "BOAT" data file contains 33 records representing the 33 observed vessels of the total 34 U.S.-registered vessels in 1987. Each record contains the number of cruises made during the year by the vessel and a list of cruise numbers, which are arranged in the order of their departure date. The "VPOP" file comprises a cumulative yearly summary record for each vessel, with sets made, days fished, and kill statistics. The "SAMP12" file is a subset of "SAMPDAT" and contains yearly or cumulative December kill statistics by trip. These three files have been used by the yearly mortality simulation for fleets of smaller size (≤ 33). Appendices 1, 3, and 4 show the three data file formats.

METHOD OF ESTIMATION

The estimates of total incidental mortality for each dolphin category and for all dolphin categories combined are computed using the ratio estimation method (Cochran, 1977) based on samples that are randomly selected from the sample space, e.g. the "SAMPDAT" data file. One of three variables can be chosen as the estimator: kill-per-day, kill-per-set or kill-per-ton. The unit 'day', 'set' or 'ton' selected is the auxiliary variable x_i where the correlated y_i is the kill obtained for each unit in the sample. Two choices are available for selection for the kill-per-ton estimator: kill-per-ton-of-total-tuna-caught or kill-per-ton-of-yellowfin-tuna-caught. The estimate of the ratio $\hat{R}$ is defined to be

$$\hat{R} = \frac{y}{x} = \frac{\Sigma\, y_i}{\Sigma\, x_i} \qquad \ldots\ldots\ldots\

where y and x are the sample totals of the y_i (kill) and x_i (days, sets or tons), respectively. The estimate of the kill total $\hat{Y}$ for a particular population is then

$$\hat{Y} = (\hat{R})(X) \quad \ldots\ldots(2)$$

where X is the population total (e.g., total days).

The approximate variance estimate of the population total estimate $\hat{Y}$ is

$$V(\hat{Y}) = \frac{N^2(1-f)}{n}\left[\frac{\sum_{i=1}^{n}[y_i - (\hat{R})(x_i)]^2}{n-1}\right] \quad \ldots\ldots(3)$$

where

f = n/N, is the sampling fraction.
N = total number of fishing trips in the population.
n = total number of sampled trips.

The standard error of $\hat{Y}$ is

$$S(\hat{Y}) = [V(\hat{Y})]^{0.5} \quad \ldots\ldots(4)$$

The upper and lower confidence limits of the total estimate are:

$$U(\hat{Y}) = \hat{Y} + z[S(\hat{Y})] \quad \ldots\ldots(5)$$

$$L(\hat{Y}) = \hat{Y} - z[S(\hat{Y})] \quad \ldots\ldots(6)$$

where z is the normal score corresponding to the chosen confidence probability (e.g., 95%).

SIMULATION PROCEDURES

Three separate procedures have been developed for various sets of estimates: one produces cumulative monthly kill estimates for each species/category of the entire observed fleet when only a certain percent of trips (records) are covered (selected); the second method produces the same statistics, except that it selects trips in a non-back-to-back fashion with 50% observer coverage; and the third method produces estimates of the yearly total kill for smaller fleets, or for foreign fleets.

MONTHLY CUMULATIVE SIMULATION METHOD

For a selected percent observer coverage of P (e.g., P = 25, 33, 50, 75, or 96%) we randomly select P% of all trips departing in January from the sample space, i.e., "SAMPDAT", as the sample data. Based on these selected trips, the monthly total estimates for each variable of interest (individual dolphin category or total dolphin mortality) are computed using Equations 1 and 2 with a

selected estimator, namely kill-per-day, kill-per-set, or kill-per-ton. The following statistics are also computed, using Equations 1 to 6: variance, upper and lower confidence limits, and length of the confidence interval (CI). Since the CI is an interval estimate of the true kill, we also keep a count of the CIs that contain the actual total kill and calculate the percentage by dividing the total count by the total number of iterations. This percentage estimates the true confidence level, which may differ from the chosen or claimed confidence level, e.g. 95%. Next, we randomly select P% of all trips that departed in February, including in the statistics all cumulative February statistics observed for the previously selected trips that left port in January. The combined total statistics are used to compute the February cumulative estimates. The process continues from month to month until the end of the year. Equation 2 is decomposed here to show the detailed calculations. Note that all statistics are cumulative figures.

$$\hat{Y}_{mj} = \frac{\sum_{k=1}^{s_m} \left[y_{mjk} \right]}{\sum_{k=1}^{s_m} \left[x_{mk} \right]} (X_m) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where

m = month index, m=1,...,12.
j = species index, j=1,...,8.
k = selected trip index.
$\hat{Y}_{mj}$ = estimated cumulative total kill for month m, species j.
s_m = cumulative total number of trips sampled for month m.
X_m = cumulative population total days, sets, or tons for month m.
x_{mk} = cumulative total days, sets, or tons for month m and kth sampled trip.
y_{mjk} = cumulative kill for month m of species j and kth sampled trip.

The simulation procedure is iterated n times, e.g., n = 500. The mean value of the n sets of independently generated estimates is used as the final simulated result (Appendix 6).

NON-BACK-TO-BACK 50% COVERAGE SIMULATION METHOD

For 50% observer coverage, a non-back-to-back method has been used to simulate the way observed vessels are actually chosen. In this method, 50% of the vessels are selected to carry observers on their first trips and every odd- numbered trip made thereafter, while the other 50% of the vessels carried observers on their even-numbered trips. Depending on the number of trips made by each vessel during the year, the total sampled trips thus selected may not be exactly 50% of the total trips (124). A separate procedure

has been developed to simulate the mortality under this sampling scheme (Figure 2).

YEARLY MORTALITY ESTIMATES FOR SMALLER FLEETS

To estimate the mortality for a fleet such as a foreign fleet that has fewer than 33 vessels, a separate simulation procedure (Figure 3) has been developed with the following steps:

1. Randomly select a fleet of Z boats from the set of 33 boats without replacement, Z = 1,..., 33.

2. Compute (add) the observed yearly total kill Y and total days X spent at sea made by these Z boats. The Y and X are the population totals for the subsequent simulation.

3. Randomly take P% of the cruises made by each of these Z boats without replacement, P = {25, 33, 50, 75, 96}.

4. Compute a yearly estimate $\hat{Y}_i$ for each percentage from the randomly selected cruises from step 3, with the ratio estimation method.

5. Repeat steps 3 and 4 n_1 times, take the averages of the total estimates over n_1 as the simulated results, and report the following statistics:

   Estimated kill $\hat{Y} = (1/n_1) \sum_{i=1}^{n_1} (\hat{Y}_i)$

   Variance of $\hat{Y}$: $V(\hat{Y}) = [1/(n_1 - 1)] \sum_{i=1}^{n_1} (\hat{Y}_i - \hat{Y})^2$

   Bias of $\hat{Y}$: $\hat{Y}_{bias} = \hat{Y} - Y$, Y from step 2.

   Relative Bias of $\hat{Y} = 100 * [(\hat{Y} - Y) / Y]$, Y from step 2.

   MSE of $\hat{Y} = V(\hat{Y}) + (\hat{Y}_{bias})^2$

   CV of $\hat{Y} = [MSE(\hat{Y})]^{0.5} / Y * 100$, Y from step 2.

6. Iterate steps 1 through 5 n_2 times and take the averages of the reported statistics as the final statistics.

Appendix 7 is an example of the simulated results for a fleet size of 10. Note that the statistics are the yearly mortality estimates instead of monthly cumulative statistics. Also note that the average of the relative biases is the average of the absolute values for each bias; since the negative sign indicates the direction of the bias vector, only the lengths of the vectors are used in the average.

COMMANDS USED TO EXECUTE THE SIMULATION PROGRAMS

Since most of our simulations are performed on IBM PCs, we illustrate commands used to execute these computer programs on a PC. The C:\> signs listed below in the command lines (enclosed in double-lined boxes) represent the IBM DOS operating system prompt, and the user's responses are bold-faced, underlined and capitalized. Before you proceed, please refer to Figures 1, 2, and 3 for properly loading all necessary files to your working disk. Note that all programs have to be run in their stated sequences. Some programs are used in more than one simulation procedure. For example, VSEL1 is used in both the "non-back-to-back 50% coverage" simulation and the "yearly mortality estimates for smaller fleets" simulation.

MONTHLY CUMULATIVE SIMULATION PROGRAMS

1. To select randomly P% of cruises:

```
C:\> PREKIL

Enter output selected cruise data file name: CRU25
Enter the value of sample coverage percentage: 25
Enter the seed for generating random numbers: 5348799
Enter the number of iterations to be performed: 500

(Program is running.....)
```

The file CRU25 thus generated contains 500 records; each is 124 bytes long. These 124 bytes (columns) are used to represent the 124 coded-cruises made during the year. Column 1 represents the first cruise and column 124 represents the last cruise made during the year. When a cruise is selected the corresponding column is coded '1', otherwise the default value '0' remains. The number 124 can be replaced by any other number if other sets of data are used.

The user may specify other values according to his/her planned experiment. The results will differ only in the output file contents. For example, if the user has specified 100 iterations, the output will contain 100 records, and if the user has specified 45% coverage, each output record will contain more 1's than the output produced by 25% coverage, since more trips will be selected at the higher percent coverage.

2. To compute monthly cumulative mortality estimates:

```
C:\> KILALL

Enter input sample data file name : SAMPDAT
Enter input population data file name: MOSUMC
Enter input selected cruise data file name: CRU25
```

```
Enter output report file name: RPT25
Choose one method of estimation
     1 = kill per day.
     2 = kill per set.
     3 = kill per ton.
:(if your answer is 3, more choices follow:)
Which tonnage to choose for the estimation?
     1 = total tuna tonnage.
     2 = total yellowfin tonnage.
:(your choice)

(Program is running......)
```

All cumulative kill estimates and their associated values for the eight dolphin species/stock categories are reported. One page is generated for each month; there are 96 pages for each simulation (see Appendix 6 for an example report page).

NON-BACK-TO-BACK 50% COVERAGE SIMULATION PROGRAMS

1. To select randomly a group of boats and compute the total statistics incurred by these boats:

```
C:\> V8EL1

Enter the number of vessels to be chosen:  33
Enter output file name for selected vessel numbers: V33
Enter the seed for generating random numbers: 3568574
How many iterations do you wish to perform: 1

(Program is running........)
```

The file, V33, (see Appendix 9 for format and example of contents) contains 33 vessel names and the total statistics that are necessary for the next program PREKIL2 to run properly. The user may specify any number of vessels to be chosen for the simulation as long as the number is less than or equal to 33. The iteration frequency of 1 is necessary in this simulation, since the actual iteration is controlled by the next program PREKIL2.

2. To select randomly 50% of cruises departing in each month with the "non-back-to-back" method, and to output the selected cruise numbers:

```
C:\> PREKIL2

Enter input selected vessel data file name: V33
Enter output file name for selected cruises: CRU50
Enter the seed for generating random numbers: 348799
Enter the desired number of iterations: 500
```

```
(Program is running.....)
```

This program takes the output file from the program VSEL1 as input and produces an output structured the same as the file produced by the program PREKIL. Although the percent coverage is fixed at 50%, the selected trips do not total exactly 50% for reasons stated earlier (see Simulation Procedure section).

3. To compute monthly cumulative mortality estimates and to report the simulation results:

```
C:\> KILALL

Enter input sample data file name : SAMPDAT
Enter input population data file name: MOSUMC
Enter input selected cruise data file name: CRU50
Enter output report file name: RPT50
Choose one method of estimation
     1 = kill per day.
     2 = kill per set.
     3 = kill per ton.
:(if your answer is 3, more choices follow:)
Which tonnage to choose for the estimation?
     1 = total tuna tonnage.
     2 = total yellowfin tonnage.
:(your choice)

(Programming is running......)
```

This is the same program described earlier. The report is produced under the 50% non-back-to-back trip selection algorithm.

YEARLY MORTALITY ESTIMATES FOR SMALLER FLEETS

1. To accumulate statistics for each vessel:

```
C:\> VSEL0

Enter output file name: VPOP

(Program is running....)
```

The output file contains the total statistics for each vessel (Appendix 4). This program only needs to be executed once for each data set.

2. To select randomly a group of boats and to compute the total statistics incurred by these boats:

```
C:\> VSEL1

Enter the number of vessels to be selected: 5
Enter output file name for selected vessel : V5
Enter the seed for generating random numbers: 38586574
Enter the desired number of iterations: 10

(Program is running.........)
```

Note that you will get one output file from this run: V5. It is a list of vessel numbers that are selected for each iteration and the total accumulated kills for these selected vessels (see Appendix 9 for format and example of contents):

3. To select randomly P% of the cruises made by each of the previously selected vessels and compute total kill estimates for a smaller fleet using the ratio estimation method and kill-per-day as the estimator:

```
C:\> VSEL2

Enter input selected vessel data file name: V5
Enter output report data file name: RPT5
Enter sample coverage percentage: 33
Enter the number of iterations for the cruise selection:5
Enter the seed for generating random numbers:  548576

(Program is running.........)
```

You will use the output file named V5 from the VSEL1 program as input. You will get 8 output files from this run, one for each dolphin species/stock category. Output files are labeled and are self explanatory. The bottom line of the report contains the averages of the column totals (Appendix 7).

RANDOM SAMPLING PROCEDURES

The simulation results are based, to a very large extent, on samples selected from the population (data). Sampling method in selecting trips or vessels is an important part of our simulations. The samples used in our simulation are selected at random without replacement from our data, which are considered as the population. There are many algorithms for random sampling, which have been discussed by Kennedy and Gentle (1980). This section describes the random sampling algorithm that we have adopted during our simulations and the method used in treating sample sizes that are not integers.

SEQUENTIAL ALGORITHM

The equal probability selection method is used to select elements (trips, vessels) from the sample space. Computer-generated random numbers play an important part in the selection method. A sample of size n is chosen from a finite number of N elements (records) in such a way that any element contained in N has an equal chance of being selected. In the implementation stage, we sequentially go through the data file, in which trips or vessels are coded and arranged in ascending order. A computer-generated random number from the uniform (0,1) distribution is produced for each trip or vessel encountered. The ith trip or vessel is included in the sample if the following condition is satisfied (Kennedy and Gentle, 1980):

$$U_i \leq (n - n_i) / (N - i + 1)$$

where

i = the coded trip (vessel) number in the population data.
U_i = the ith generated random number from uniform (0,1).
n_i = the number of trips (vessels) selected before the ith trip (vessel)
n = the number of trips (vessels) to be selected (sample size).
N = total number of trips (vessels) in the population.

This algorithm produces exactly n sample units. Although no method is absolutely the best, because governing factors such as efficiency in storage requirements, efficiency in time, relative sizes of n and N vary from one situation to another (Kennedy and Gentle, 1980), we chose the above described sequential method over a commonly used simple rejection method, (or acceptance method). The rejection method rejects the ith trip when it is already included in the sample, where $i = (U_i * N + 1)$; otherwise, it accepts it in the sample. We did not use the rejection method because the value of n/N is quite large when the percent coverage is high, where n is the selected trips and N is the total trips in the population. As n gets closer to N, the rejection method becomes very inefficient in finding an unduplicated sample. Sampling at 100% coverage is impossible when the rejection method is used. When sampling at 100% coverage, the simulated total should equal the population total. Differences between the two would indicate numerical inaccuracies somewhere in the computation processes.

TREATMENT OF NON-INTEGER SAMPLE SIZES

Since one cannot sample a fraction of a trip, the nearest integer is taken when the calculated sample size is not an integer (e.g., sample size = 25% * 11 = 2.75). The random number generated from U(0,1) is used to decide whether to pick the larger integer or the smaller integer to be the sample size. This would reduce the degree of over- or under-sampling induced by the rounding error

problem. In the above example, if the random number U_i for iteration i is less than the fractional part of the sample size (0.75) take the greater integer (3); otherwise, take the smaller integer (2) as the sample size. In the long run (e.g., 500 iterations) the sample size thus determined by the probability selection method will converge on its true size, which is equal to P% multiplied by the total number of trips. The following table lists the monthly sample sizes from one simulation of 500 iterations and their expected sample sizes at various percent coverages. The simulation sample size is the average sample size per iteration.

Table 2. Expected sample sizes and mean values of the actual sample sizes

MONTH:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
P = POPULATION TOTAL	20.00	27.00	41.00	52.00	63.00	73.00	81.00	88.00	98.00	115.00	119.00	124.00
25% EXPECTED SAMPLE SIZE	5.00	6.75	10.25	13.00	15.75	18.25	20.25	22.00	24.50	28.75	29.75	31.00
SIMULATION RESULTS	5.00	6.74	10.24	12.99	15.75	18.26	20.26	22.03	24.51	28.78	29.78	31.01
33% EXPECTED SAMPLE SIZE	6.60	8.91	13.53	17.16	20.79	24.09	26.73	29.04	32.34	37.95	39.27	40.92
SIMULATION RESULTS	6.60	8.93	13.54	17.14	20.74	24.02	26.67	29.00	32.32	37.92	39.25	40.91
50% EXPECTED SAMPLE SIZE	10.00	13.50	20.50	26.00	31.50	36.50	40.50	44.00	49.00	57.50	59.50	62.00
SIMULATION RESULTS	10.00	13.53	20.53	26.03	31.56	36.56	40.56	44.00	49.00	57.47	59.47	61.98
75% EXPECTED SAMPLE SIZE	15.00	20.25	30.75	39.00	47.25	54.75	60.75	66.00	73.50	86.25	89.25	93.00
SIMULATION RESULTS	15.00	20.30	30.81	39.09	47.35	54.83	60.83	66.04	73.53	89.27	93.02	93.02
96% EXPECTED SAMPLE SIZE	19.20	25.92	39.36	49.92	60.48	70.08	77.76	84.48	94.08	110.40	114.24	119.04
SIMULATION RESULTS	19.20	25.94	39.35	49.92	60.48	70.10	77.77	84.51	94.13	110.44	114.27	119.08

STATISTICS REPORT FOR THE SIMULATION

The monthly cumulative mortality estimate simulation produces one page of output for each species and each month. Therefore, a total of 96 pages of output will be generated from one simulation with a selected percent coverage. Appendix 6 is an example of results for one species of a particular month from one simulation. For the simulation of the yearly mortality estimation of smaller fleets, the number of output lines increases when higher number of iterations are chosen. Appendix 7 is an example of the simulated results from the yearly simulation for a fleet size of 10. Listed below are the equations used in deriving these reported statistics for a particular variable (individual dolphin category mortality or total dolphin mortality) of interest. In order to reduce the complexity of the variables, we define symbols with their implied month (m) and species(j) indices.

SYMBOLS AND DEFINITIONS

n = number of iterations.

P = percent coverage chosen for the simulation, P =1,...,100.

T = total number of trips in the population.

S = average sample size for month m.

s_i = total cumulative number of trips sampled for iteration i and month m.

$\hat{Y}_i$ = estimated total kill from iteration i for month m and species j.

Y = total cumulative population kill for month m and species j.

U_i = upper confidence limit of the total kill estimate $\hat{Y}_i$ of the iteration i for month m and species j.

L_i = lower confidence limit of the total kill estimate $\hat{Y}_i$ of the iteration i for the m and species j.

$\hat{Y}$ = total kill estimate for month m and species j.

$\hat{Y}_{bias}$ = bias of $\hat{Y}$.

$\hat{Y}_{r.b.}$ = relative bias of $\hat{Y}$.

$V(\hat{Y})$ = variance of $\hat{Y}$.

$MSE(\hat{Y})$ = mean square error of $\hat{Y}$.

$CV(\hat{Y})$ = coefficient of variation of $\hat{Y}$.

MEAN $[SE(\hat{Y})]$= mean of the standard Error of $\hat{Y}$.

SD $[SE(\hat{Y})]$ = standard deviation of the standard error of $\hat{Y}$.

CV $[SE(\hat{Y})]$ = coefficient of variation of the Standard error of $\hat{Y}$.

EQUATIONS FOR THE MONTHLY CUMULATIVE MORTALITY ESTIMATES

$$S = (1/n)\left[\sum_{i=1}^{n}(s_i)\right] \quad \text{.....(8)}$$

where $s_i=[(P\%)(t_1) + (P\%)(t_2) +...+ (P\%)(t_m)]$, and

t_m = the number of trips departed in month m.

$$\hat{Y} = (1/n) \left[\sum_{i=1}^{n} (\hat{Y}_i) \right] \quad \ldots\ldots (9)$$

$$\hat{Y}_{bias} = \hat{Y} - Y \quad \ldots\ldots (10)$$

$$\hat{Y}_{r.b.} = 100 * (\hat{Y}_{bias} / Y) \quad \ldots\ldots (11)$$

$$V(\hat{Y}) = [1/(n-1)] \left[\sum_{i=1}^{n} (\hat{Y}_i - \hat{Y})^2 \right] \quad \ldots\ldots (12)$$

$$MSE(\hat{Y}) = V(\hat{Y}) + (\hat{Y}_{bias})^2 \quad \ldots\ldots (13)$$

$$CV(\hat{Y}) = \{ [MSE(\hat{Y})]^{0.5} / Y \} * 100 \quad \ldots\ldots (14)$$

%CIs CONTAINING POPULATION TOTAL (Y)

$$= (F / n) \quad \ldots\ldots (15)$$

where $F = \sum_{i=1}^{n} (f_i)$; { $f_i = 1$ for $L_i < Y < U_i$, $= 0$ otherwise }

$$\text{AVERAGE LENGTH OF CI.} = (1/n) \left[\sum_{i=1}^{n} (U_i - L_i) \right] \quad \ldots\ldots (16)$$

$$\text{MEAN } [SE(\hat{Y})] = (1/n) \left[\sum_{i=1}^{n} [V(\hat{Y}_i)]^{0.5} \right] \quad \ldots\ldots (17)$$

where $V(\hat{Y}_i)$ from equation (3)

$$SD[SE(\hat{Y})] = \{ V[SE(\hat{Y})] \}^{0.5} \quad \ldots\ldots (18)$$

where $V[SE(\hat{Y})] = \frac{1}{n-1} \sum_{i=1}^{n} \left[[V(\hat{Y}_i)]^{0.5} - \text{MEAN } [SE(\hat{Y})] \right]^2$;

and $V(\hat{Y}_i)$ from equation (3).

$$CV[SE(\hat{Y})]*100\% = \{ SD[SE(\hat{Y})] / \text{MEAN}[SE(\hat{Y})] \} * 100 \quad \ldots\ldots (19)$$

SPECIAL NOTATION

The observed kill statistics vary from one category of dolphins to the other. For some categories such as the striped dolphin there were no kills or very few kills recorded for some days or even for the entire month (Appendix 5). Under these conditions, the sample can only consist of all zero-kills. Therefore, we have used '0' values to fill in all reported statistics related to estimated total ($\hat{Y}$), except the CVs, where -99.99 is used, and the %CI containing population kill (= 100%).

COMPUTERS AND SOFTWARE USED

The cumulative monthly mortality simulation was originally performed on a CRAY X-MP/48 supercomputer at the San Diego Supercomputer Center (SDSC). This machine has four CPUs, each providing a theoretical peak speed of 840 million floating-point operations per second (MFLOPS). It runs an interactive operating system called CRAY Time-Sharing System (CTSS), which supports a wide variety of utilities, programming languages, application softwares etc. The line text editor 'tedi', vectorized Cray FORTRAN compiler (CFT 1.14), and dynamic debugger (DDT) were used to write, test, debug and execute the simulation programs.

Intrinsic routine RANF of the CFT was called to obtain a random number which has a uniform distribution over the interval (0,1). The Fortran subroutine 'SMPRR' of the STAT/LIBRARY from The International Mathematical and Statistical Library (IMSL) was used to compute the population total, with the ratio estimation method.

The simulation programs have been converted and compiled with the RM/FORTRAN (Version 2.42) compiler to run on any IBM PC. The RANF random number function from the CRAY replaced by a routine named RAN1 (Press et al., 1986), and the SMPRR routine has been re-written following equations extracted from Cochran (1977). Both routines are written in RM/FORTRAN language for the IBM PC. The SMPRR adopts the same format that the IMSL uses but with fewer parameters passed between programs.

DISCUSSION

The ratio estimate used here for dolphin mortality has a bias of order 1/n (Cochran 1977). As n becomes large the bias becomes negligible, but when the sample size is small, i.e. is less than 30, the confidence limits which are computed using a normal approximation may not be very accurate. For this reason, numerous warning messages about the sample sizes were generated by the SMPRR subroutine of the IMSL/STAT library during our simulations. The frequency of the warnings (I/Os) made the CPU time used inversely related to the sampling coverage. For the smaller sampling coverage, the occurrences of sampled trips per month less than 30 were more frequent (Table 2) and thus activated the warning routine more frequently. We have written our own ratio estimation routine to replace the IMSL packages in order to eliminate the problem of overwhelming CPU usage due to error messages. Other users are warned to take note of this problem.

Because the statistics are computed from simulated estimates, and estimates are calculated from randomly selected samples, the same analysis of a data set when carried out twice with different seeds for generating the random numbers will in general yield different values. The confidence intervals calculated from the simulated values will vary as well. In general, the variability decreases as the number of simulations increases.

Two methods are used to compute the coefficient of variation of the total estimates. One computes the variance and the standard error directly from Equations 3 and 4, and the mean value MEAN [SE($\hat{Y}$)] (Equations 17 and 18) over the SE computed from the simulation is taken as the final SE. The coefficient of variation - CV [SE($\hat{Y}$)] (Equation 19) - is thus derived from this SE. In the second method, the coefficient of variation, CV($\hat{Y}$) (Equation 14), uses the variance estimated from the variation of the total estimates about their own grand mean (Equation 12). These two CVs vary slightly, with the latter having the smaller values (Appendix 8).

Out of 124 trips, only 12 recorded any common dolphin kill during 1987. This may be due to a number of reasons, such as that the cruises in 1987 did not go to areas where common dolphins occurred, or that some cruises tended not to set nets on common dolphins. Also, 594 of the 882 common dolphins killed in 1987 were killed on a single trip. The high kill trip for common dolphin and the rare observations can produce estimates with large bias and variance. The percentages of sets made on common dolphins is quite different between the U.S. fleet and the foreign fleet, i.e., 0.9% for the U.S. fleet and 4.2% for the foreign and U.S. combined. The total common dolphin kill is also different between the two fleets, e.g., the kill is 7% of total kill of all species for the U.S. fleet while it is 21% of the foreign and U.S. combined total kill.

Thus it is clear that the 1987 data may not be typical for all species, all years and all fleets. Use of these data in other simulations should be done with some caution.

Common dolphins do not tend to associate with other dolphins in the ETP. Therefore, when only kills for "common dolphin" and "unidentified dolphins" are recorded for a set, these unidentified dolphins are most likely common dolphins (a portion of the dead dolphins was not seen clearly during the set, and therefore were not identified). To determine the species/category-group (i.e., common or non-common dolphins) for sets where there were zero dolphins killed, it is necessary to use other available data such as "capture information" or "sighting information" in interpreting the data. It is also a good practice to do so for mixed sets where the total kills are greater than zero. A mixed set is a set for which species composition contains both common dolphins and non-common dolphins. The following table lists possible cases when allocating mixed sets[2] to their appropriate groups (common or non-common):

---

[2] Refer to memo, 'Clarification and redefinition of classification procedures for data pertaining to the Comparable Mortality Rate test', by C. Lennert and D. DeMaster dated Oct. 19, 1989.

Table 3. Possible set classification scheme for mixed sets. N is an integer number greater than zero. The symbol "*" represents any number ≥ 0.

Total Kill	Total Common Kill	Total Common Capture	Total Common Sighting	Allocated Group Category
N	> 50% Total Kill	*	*	Common
N	≤ 50% Total Kill	*	*	Non-common
0	0	> 50% Total Capture	*	Common
0	0	≤ 50% Total Capture	*	Non-common
0	0	0	> 50% Total Sighting	Common
0	0	0	≤ 50% Total Sighting	Non-common

ACKNOWLEDGEMENTS

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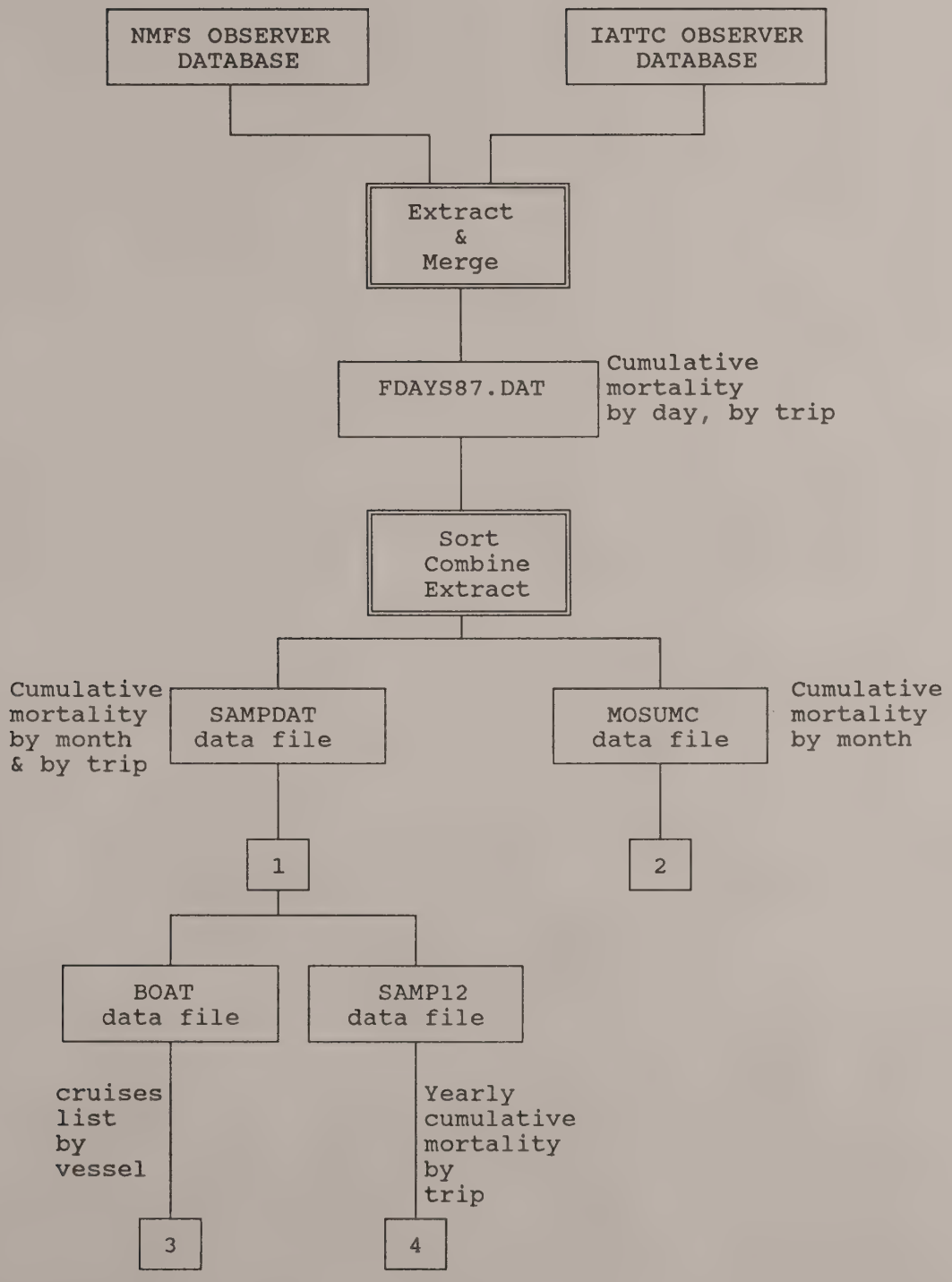


Figure 1. Schematic diagram of data flow.

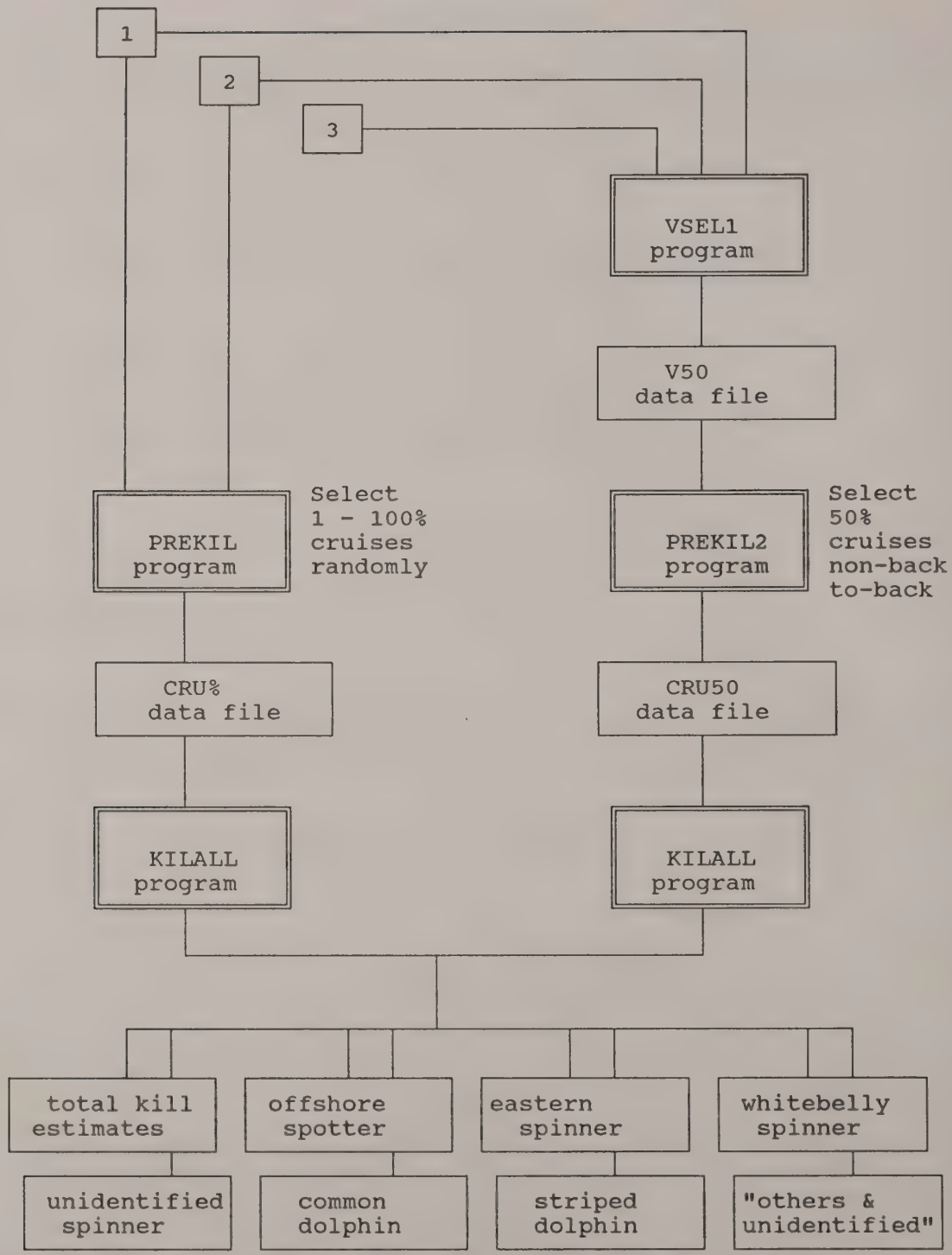


Figure 2. Simulation diagram of cumulative monthly mortality estimates obtained by varying the percent coverage.

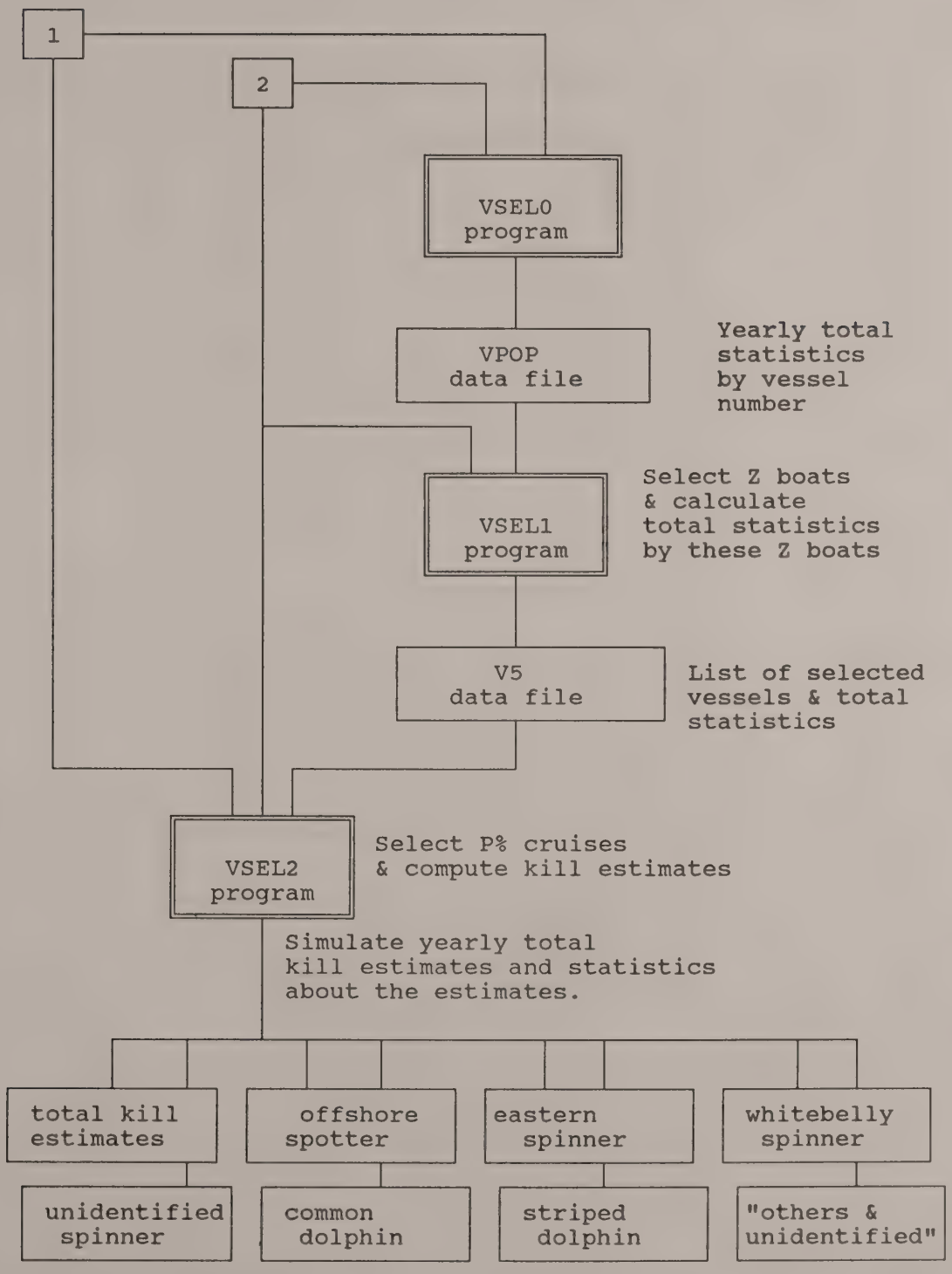


Figure 3. Simulation diagram of yearly mortality estimates obtained by varying the fleet sizes and percent coverage.

Appendix 1. Format for "SAMPDAT" or "SAMP12" data files

Columns	VARIABLE DESCRIPTION	FORMAT
1 - 3	Coded trip number (1 - 124)	I3
4 - 4	New trip for the month (1=yes, 0=no)	I1
5 - 5		1X
6 - 7	Month (1 - 12)	I2
8 - 8		1X
9 - 12	Cruise number	I4
13 - 13		1X
14 - 16	Total days spent at sea *	I3
17 - 17		1X
18 - 20	Total number of dolphin sets made *	I3
21 - 24	Total dolphin mortality *	I4
25 - 28	Kill for the Offshore spotted *	I4
29 - 32	Kill for the Eastern spinner *	I4
33 - 36	Kill for the Whitebelly spinner *	I4
37 - 40	Kill for the Unidentified spinner *	I4
41 - 44	Kill for the Common dolphin *	I4
45 - 48	Kill for the Striped dolphin *	I4
49 - 52	Kill for Other & unidentified dolphins *	I4
53 - 57	Total tons tuna caught *	I5
58 - 62	Total tons yellowfin caught *	I5

Note: All * marked items include figures cumulated from January 1st through end of the recorded month.

Appendix 2. Format for the "MOSUMC" Data File

Columns	VARIABLE DESCRIPTION	FORMAT
1 - 2	Month (1 - 12)	I2
3 - 5	Total vessels *	I3
6 - 9	Total days spend at sea *	I4
10 - 13	Total dolphins sets made *	I4
14 - 18	Total dolphin mortality *	I5
19 - 22	Kill for the Offshore spotted *	I4
23 - 26	Kill for the Eastern Spinner *	I4
27 - 30	Kill for the Whitebelly spinner *	I4
31 - 34	Kill for the Unidentified spinner *	I4
35 - 38	Kill for the Common dolphin *	I4
39 - 42	Kill for the Striped dolphin *	I4
43 - 46	Kill for Other & unidentified dolphins *	I4
47 - 51	Total tons tuna caught *	I5
52 - 56	Total tons yellowfin caught *	I5

Note: All * marked items include figures cumulated from January 1st through end of the recorded month.

Appendix 3. Format for the "BOAT" data file

Columns	VARIABLE DESCRIPTION	FORMAT
1 - 2	Vessel number (1-33)	I2
3 - 4	Number of cruises made by the vessel (1-6)	I2
5 - 9	Coded cruise no. of the 1st cruise	I5
10 - 14	Cruise no. of the 1st cruise	I5
15 - 19	Coded cruise no. of the 2nd cruise	I5
20 - 24	Cruise no. of the 2nd cruise	I5
25 - 29	Coded cruise no. of the 3rd cruise	I5
30 - 34	Cruise no. of the 3rd cruise	I5
35 - 39	Coded cruise no. of the 4th cruise	I5
40 - 44	Cruise no. of the 4th cruise	I5
45 - 49	Coded cruise no. of the 5th cruise	I5
50 - 54	Cruise no. of the 5th cruise	I5
55 - 59	Coded cruise no. of the 6th cruise	I5
60 - 64	Cruise no. of the 6th cruise	I5

Appendix 4. Format for the "VPOP" Data File

Columns	VARIABLE DESCRIPTION	FORMAT
1 - 3	Vessel number (1 - 33)	I3
4 - 6	Number of cruises made by the vessel	I3
7 - 11	Number of days fished by the vessel	I5
12 - 16	Total number of dolphin sets made	I5
17 - 21	Total dolphin mortality	I5
22 - 26	Kill for the Offshore spotted	I5
27 - 31	Kill for the Eastern spinner	I5
32 - 36	Kill for the Whitebelly spinner	I5
37 - 41	Kill for the Unidentified spinner	I5
42 - 46	Kill for the Common dolphin	I5
47 - 51	Kill for the Striped dolphin	I5
52 - 56	Kill for Other & unidentified dolphins	I5
57 - 61	Total tons tuna caught	I5
62 - 66	Total tons yellowfin caught	I5

Appendix 5. Monthly cumulative statistics on observed trips in 1987 (MOSUMC)

MO	VES	DAY	SET	TOT	OFS	EAS	WBS	UNS	COM	STR	OTH	TUN	YFT
1	20	425	241	818	333	222	13	0	0	0	250	4124	4123
2	27	1006	670	1844	835	669	32	0	0	0	308	12218	12212
3	41	1578	1047	2517	1265	839	36	1	50	0	326	18532	18509
4	52	2221	1436	2898	1485	902	43	1	137	0	330	24744	24581
5	63	2855	1864	3988	2339	1016	152	1	147	0	333	32940	32696
6	73	3521	2193	5586	3596	1087	387	9	159	0	348	40398	40151
7	81	4210	2515	6971	4634	1249	557	9	173	0	349	46915	46647
8	88	4917	2948	8206	5417	1389	848	23	173	0	356	54803	54499
9	98	5451	3351	9163	6221	1506	851	24	191	3	367	62315	61791
10	115	6093	3630	10300	7002	1791	887	30	191	4	395	66630	66061
11	119	6901	4066	12356	7794	2364	962	54	714	8	460	73050	72299
12	124	7595	4312	13390	8437	2557	981	55	882	8	470	75799	75040

MO = Month
VES = Cumulative number of vessels at sea by month.
DAY = Cumulative number of days at sea by month.
SET = Cumulative number of sets made at sea by month.
TOT = Cumulative number of total dolphin killed by month.
OFS = Cumulative number of offshore spotted kills by month.
EAS = Cumulative number of eastern spinner kills by month.
WBS = Cumulative number of whitebelly spinner kills by month.
UNS = Cumulative number of unidentified spinner kills by month.
COM = Cumulative number of common dolphin kills by month.
STR = Cumulative number of striped dolphin kills by month.
OTH = Cumulative number of "others and unidentified" dolphin kills.
TUN = Cumulative number of total tonnage tuna caught by month.
YFT = Cumulative number of total tonnage yellowfin caught by month.

Appendix 6. Example of monthly cumulative mortality estimate report

SIMULATED MONTHLY CUMULATIVE ESTIMATES OF DOLPHIN MORTALITY
BASED ON UNSTRATIFIED RATIO ESTIMATES

No. of Independent Samples: 500
Random number seed value : 9871238.
Confidence Intervals : 95.0%

Month	Species/Estimator	Population Trips	Days	kill
Nov	Total kill /Day	119	6901.	12356.

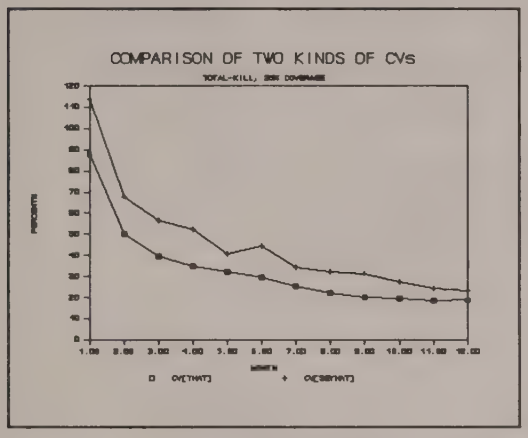
PERCENT COVERAGE	50.%
SAMPLE SIZE	59.47
MEAN (YHAT)	12388.07
BIAS (YHAT)	32.07
REL BIAS(YHAT)*100%(	0.26)
V (YHAT)	0.19537049E+07
	(0.13977499E+04)
MSE(YHAT)	0.19547332E+07
	(0.13981177E+04)
CV(YHAT)*100%	11.32
%CI 1 CONT P.KILL	91.40
AVE. LEN. CI.(1)	5175.37
MEAN(SEYHAT)	1320.25
S.D.(SEHYAT)	0.20408584E+03
CV(SEYHAT)*100%	0.15458163E+02

Appendix 7. Example of smaller fleet simulation report

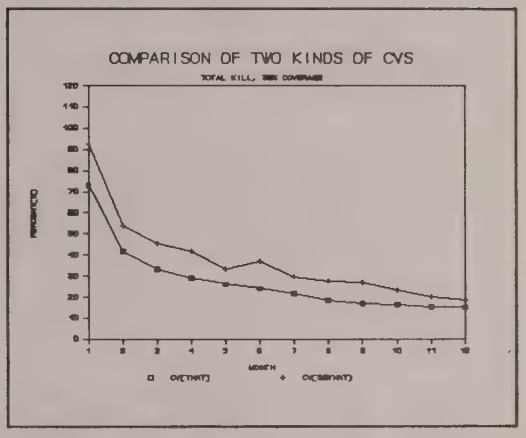
Species: Total kill
Number of boats(fleet size): 10
Random seed number(boat selection): 394871
Number of iterations(boat selection): 10
Percent coverage: 50%
Number of iterations(cruise selection): 50
Random seed number(cruise selection): 298375

Trip	Population Day	Kill	Samp Size	Mean Kill (YHAT)	Rel-bias *100%	C.V. *100%	Variance (YHAT)	MSE (YHAT)	SQRT (MSE)
37	2300.	4398.	17.0	4063.39	-7.61	15.41	347503.6	459464.7	677.8
45	2601.	4275.	21.0	4089.66	-4.34	14.79	365170.4	399522.3	632.1
35	2043.	4589.	16.0	4541.13	-1.04	19.18	772534.8	774826.6	880.2
37	2401.	4416.	18.0	4466.76	1.15	15.70	478260.8	480837.3	693.4
35	2322.	4169.	16.0	4374.47	4.93	16.86	451637.4	493856.9	702.7
37	2202.	3779.	17.0	3431.97	-9.18	19.64	430565.2	550993.9	742.3
35	2249.	3914.	15.0	3853.16	-1.55	20.54	642587.6	646289.6	803.9
33	2136.	3957.	15.0	4041.20	2.13	13.48	277231.3	284321.6	533.2
36	2319.	3719.	15.0	3599.70	-3.21	23.02	718525.4	732756.8	856.0
37	2315.	4150.	17.0	3904.99	-5.90	18.12	505350.5	565379.2	751.9
36	2289.	4137.	16.7	4036.64	4.10	17.67	498936.7	538824.9	727.4

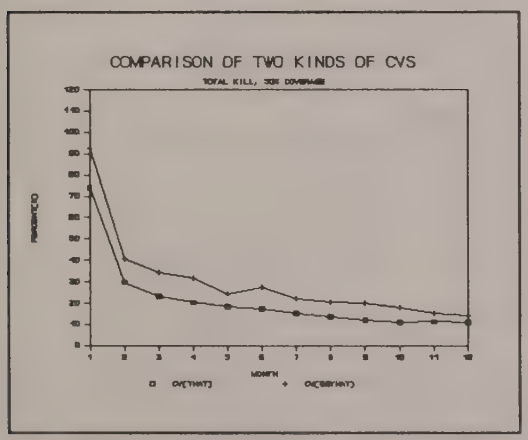
Appendix 8. Comparison of two kinds of CVS



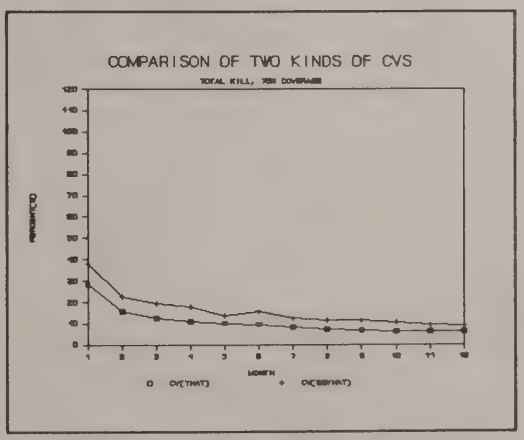
TOTAL-KILL, 25% COVERAGE



TOTAL-KILL, 33% COVERAGE



TOTAL-KILL, 50% COVERAGE



TOTAL-KILL, 75% COVERAGE

Appendix 9. Format of the output file from VSEL1.FOR

Columns	VARIABLE DESCRIPTION	FORMAT
	1st record	
1 - 5	Fleet size (number of boats)	I5
6 - 10	Number of iterations	I5
11 - 20	Seed for the random number	I10
	2nd record	
1 - 3	First selected vessel number	I3
4 - 6	Second selected vessel number	I3
7 - 9	Third selected vessel number	I3
10 - 12	Fourth selected vessel number	I3
"	"	
	3rd record	
1 - 3	Iteration number	I3
4 - 6	Vessel number (1 - 33)	I3
7 - 9	Number of cruises made by the vessel	I3
10 - 14	Number of days fished by the vessel	I5
15 - 19	Total number of dolphin sets made	I5
20 - 24	Total dolphin mortality	I5
25 - 29	Kill for the Offshore spotted	I5
30 - 34	Kill for the Eastern spinner	I5
35 - 39	Kill for the Whitebelly spinner	I5
40 - 44	Kill for the Unidentified spinner	I5
45 - 49	Kill for the Common dolphin	I5
50 - 54	Kill for the Striped dolphin	I5
55 - 59	Kill for Other & unidentified dolphins	I5
60 - 64	Total tons tuna caught	I5
65 - 69	Total tons yellowfin caught	I5
	repeat 2nd and 3 record for n iteration times	
	.....	

Example of an actual output:

```
    5    5    492871
  1  3 16 22 31
  1 29  1258  675 1369 1144  114   88    3    2    0   1810053 9857
  1  9 12 22 25
  2 22  1371  787 2089 1585  348  130    4    0    3   191265612401
  5 12 14 27 31
  3 18  1176  676 2026  728  432   62    4  764    4   321085910628
  2  9 27 29 30
  4 20  1241  726  968  670  175   94    3   12    0   141091410826
  5  8 15 22 26
  5 22  1224 835  2619 1654  683  159   37    0    2   841724817008
```

Appendix 10. Program Listings

```
C*****************************************************************
C
C    PROGRAM: VSEL0.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     To calculate total statistics for each vessel.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        FEBRUARY 14, 1989
C
c    DESCRIPTION:
C
c    1.   The program reads in the yearly statistics for each
c         trip from the 'SAMP12' data file and stores the:
c         information in memory.
c
c    2.   It then reads in from Unit 1, the 'BOAT' data file,  a
c         record which contains a vessel number, the number of
c         trips the vessel made during the year, and all
c         individual trip data.
c
c    3.   All statistics for this vessel are accumulated and
c         output to an output file.
c
c    INPUT:       UNIT 1  - BOAT
C                 UNIT 2  - SAMP12
C
c    OUTPUT:      UNIT 11 - VPOP
c
c    SUBROUTINES: NONE
C
C    TO COMPILE:    C:\>RMFORT VSEL0
C
C    TO LINK:       C:\>PLINK86 FI VSEL0
C
C    TO EXECUTE:    C:\>VSEL0
C
C*****************************************************************
      program vsel0
      implicit integer(a-z)
      dimension sortn(6),crn(6),days(124),kill(10,124)
     -,tkill(10),xsets(124)
      CHARACTER*7 in1,out1,out2
C-----------------------------------------------------------------
```

```
C  format statement
C-----------------------------------------------------------------
 101  format(a)
 104  format(2i3,12i5)
 105  format(i3,9x,12i4)
 106  format(i2,i3,2i4,i5,7i4,2i5)
 107  format(i2,i2,12i5)
C-----------------------------------------------------------------
c  I/O set up
C-----------------------------------------------------------------
      print *,'Enter output file name : '
      read(5,101)out1
      open(unit=1,file='boat',status='old',blank='zero')
      open(unit=2,file='samp12',status='old',blank='zero')
      open(unit=11,file=out1,status='new')
C-----------------------------------------------------------------
c read in data for each cruise
C-----------------------------------------------------------------
      do 97 ii=1,124
        read(2,105,end=999)j,days(j),xsets(j),(kill(i,j),i=1,10)
  97  continue
      close(unit=2)
C-----------------------------------------------------------------
c reset values
C-----------------------------------------------------------------
      do 98 j=1,33
        tdays=0
        tsets=0
        do 93 jj=1,10
          tkill(jj)=0
  93    continue
C-----------------------------------------------------------------
c read in cruise information for each vessel in sequence
C-----------------------------------------------------------------
        read(1,107,end=999)ven,no,(sortn(i),crn(i),i=1,no)
        do 96 jj=1,no
          ns=sortn(jj)
          tsets=tsets+xsets(ns)
          tdays=tdays+days(ns)
          do 96 k=1,10
            tkill(k)=tkill(k)+kill(k,ns)
  96    continue
        write(11,104)ven,no,tdays,tsets,(tkill(k),k=1,10)
  98  continue
      go to 1000
 999  continue
        print *,'End of file encountered '
1000  continue
      close(unit=1)
      close(unit=11)
      stop
      end
```

```
C*****************************************************************
C
C    PROGRAM: VSEL1.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
c    PURPOSE:     1.  To select randomly a group of boats.
C                 2.  To compute the total statistics incurred by
c                     these boats.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
c                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        FEBRUARY 9, 1989
C
c    DESCRIPTION:
C
c    1.   The program sequentially goes through boats 1 to 33 and
c         generates a no. Ui from uniform (0,1).  It includes the
c         ith boat in the sample if
c              Ui <=  ( n - ni ) / N - i + 1
c
c         where ni is the number of boats selected prior to the
c         encounter of the ith boat. i=1,2,3,...,N.  N is the
c         total number of boats, which is 33.
c
C    2.   It calculates the total statistics incurred by these
c         boats.
c
c    3.   It iterates the selection n times (user-defined), and
c         then outputs all statistics to an output file.
c
c    INPUT:     UNIT 3  - BOAT
C               UNIT 4  - VPOP
C
c    OUTPUT:    UNIT 1  - User-supplied-file name
C
C               1st record:  Number of vessels to be selected,
c               Number of iterations and seed, format (2i5,i10)
c
c               2nd record:  List of selected vessel numbers.
c               format(33i3)
c
c               3rd record:  total statistics.
C
c    SUBROUTINES: RAN1.FOR - To generate uniformly distributed
c                            U(0,1) random numbers.
c
```

```
C    TO COMPILE:    C:\>RMFORT VSEL1
C
C    TO LINK:       C:\>PLINK86 FI VSEL1,RAN1
C
C    TO EXECUTE:    C:\>VSEL1
C
c    Enter the number of vessels to be selected:
c    Enter the output file name for selected vessels:
c    Enter the seed for generating random numbers:
c    Enter the desired number of iterations:
c
C*****************************************************************
      PROGRAM VSEL1
      dimension nsel(33),no(33),numc(33),nov(33)
      integer kill(10,124),xset(124),tkill(10)
      integer ven,sortn(33,6),days(124)
      integer tset,tday
      CHARACTER*7 in1,out1,out2
C-----------------------------------------------------------------
c format statements
c-----------------------------------------------------------------
 101  format(a)
 103  format(i4)
 104  format(i8)
 105  format(33i3)
 106  format(2i5,i10)
 107  format(i2,i2,12i5)
 108  format(2i3,12i5)
 111  format(i3,9x,12i4)
C-----------------------------------------------------------------
c  input output file set up....
c-----------------------------------------------------------------
ccc   call link("read5,unit5=tty,print6,unit6=tty//")
      print *,'Enter the number of vessels to be selected: '
      read(5,103)nves
      print *,'Enter output file name for selected vessels:'
      read(5,101)out1
      print *,'Enter the seed for generating random numbers: '
      print *,'Choose large integer number 6 digits - 8 digits: '
      read(5,104)nseed
      print *,'Enter the desired number of iterations:'
      read(5,103)irp
      open(unit=1,file=out1,status='new')
      open(unit=3,file='boat',status='old',blank='zero')
      open(unit=4,file='vpop',status='old',blank='zero')
      iseed=-iabs(nseed)
      r=ran1(iseed)
C-----------------------------------------------------------------
c read in the # of cruises and the cruise numbers for each boat.
c-----------------------------------------------------------------
      do 98 j=1,33
        read(3,107,end=999)ven,numc(ven),(sortn(ven,i),ncrn,
     -  i=1,numc(ven))
  98  continue
      close(unit=3)
```

```
C-----------------------------------------------------------------
c read in total cruises, days, sets & kills made by each vessel
C-----------------------------------------------------------------
      do 97 jj=1,33
        read(4,108,end=999)j,nov(j),days(j),xset(j),
     -   (kill(i,j),i=1,10)
  97  continue
      close(unit=4)
      write(1,106)nves,irp,nseed
C-----------------------------------------------------------------
c  simulation starts
C-----------------------------------------------------------------
      do 500 ir=1,irp
        ntot=0
        tset=0
        tday=0
        do 510 i=1,10
          tkill(i)=0
 510  continue
C-----------------------------------------------------------------
c  randomly choose nves boats
C-----------------------------------------------------------------
      ni=0
      do 501 i=1,33
        p=ran1(1)
        ps1=float(nves-ni)/float(33-i+1)
        if(p.le.ps1)then
c                              ith vessel is included
          nn=ni+1
          tday=tday+days(i)
          tset=tset+xset(i)
          ntot=ntot+nov(i)
          do 505 ii=1,10
            tkill(ii)=tkill(ii)+kill(ii,i)
 505      continue
          nsel(nn)=i
          no(i)=No(i)+1
          if(ni.ge.nves)go to 300
          ni=ni+1
        end if
 501  continue
 300  continue
      write(1,105)(nsel(j),j=1,nves)
      write(1,108)ir,ntot,tday,tset,(tkill(j),j=1,10)
 500  continue
 999  print *,'simulation stops'
      close(unit=1)
      stop
      end
```

```
C*****************************************************************
C
C    PROGRAM: VSEL2.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     1.  To select randomly P% of the cruises made by
c                    each of the previously selected vessels.
C
C                 2.  To compute total kill estimates for a
C                     smaller fleet using ratio estimation
C                     method with kill/day as the estimator.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        FEBRUARY 14, 1989
C
C    DESCRIPTION:
C
C    1.  The program reads in vessel numbers (population) and the
C        population statistics from Unit 2.
C
C    2.  It then decides how many and which cruises are to be
c        selected for a given percent coverage by an equal
c        probability selection method.
C
C    3.  It calculates the total kill estimates based on
c        statistics for by these selected cruises.
C
C    4.  Mean values of the average estimates of each group
c        vessel of size M are taken as the final  statistics.
c
C    INPUT:     UNIT 1  - BOAT
C               UNIT 2  - V% (output from VSEL1.FOR)
C
C               UNIT 3  - SAMP12
C
C    OUTPUT: * UNIT 11 - Output estimates for total kill
C               UNIT 12 - "   for Offshore spotted
C               UNIT 13 - "   for eastern spinner
C               UNIT 14 - "   for whitebelly spinner
C               UNIT 15 - "   for unidentified spinner
C               UNIT 16 - "   for common dolphin
C               UNIT 17 - "   for striped dolphin
C               UNIT 18 - "   for "others and unidentified"
C    *  A user-supplied file name concatenated with the suffix
C       of 1 - 8 are used to name these 8 output files.
```

```
C
C    SUBROUTINES: SMPRR-Computes statistics for inferences
C                      regarding the population total using
C                      ratio estimation method.
c
C                 RAN1- To genearage uniformly distributed
C                      U(0,1) random numbers.
C
C    TO COMPILE:  C:\>RMFORT VSEL2
C
C    TO LINK:     C:\>PLINK86 FI VSEL2,SMPRR,RAN1
C
C    TO EXECUTE:  C:\>VSEL2
C
c    Enter input selected vessel data file name:
C    Enter output report data file name:
C    Enter sample coverage percentage:
C    Enter the desired number of iterations for selecting
c    cruises:
C    Enter the seed for generating random numbers:
C*****************************************************************
      program VSEL2
      dimension no(124),ipick(124),nsel(33),numc(33),
     -          sortn(33,6),crn(33,6),pc(100,6),npc(100,6)
     -         ,stat(20),ysum(8),yysum(8),yymean(8)
     -         ,ccv1(8),rrybias(8),mmse(8),vvhat(8),ssmse(8)
     -         ,temp(8)
      real kill(8,124),kfound(124,8),dfound(124),xday(124),
     -     xset(124),sums2(8),sums4(8),rsums2(8),rsums4(8)
      real mse,mmse
      integer ven,sortn,crn
      CHARACTER*7 in1,out1,out2
      character*12 kvar(10)
      data kvar/'Total kill  ','Offshor spin','Estern spin '
     -     ,'White spin  ','Unknown     ','Comm dolphin',
     -      'Striped kill','Other kill  ','tot tuna ton',
     -      'tot Y.F. ton'/
C-----------------------------------------------------------------
C format statements
C-----------------------------------------------------------------
 100  format(124i1)
 101  format(a)
 102  format(f5.1)
 103  format(i4)
 104  format(i10)
 105  format(33i3)
 106  format(2i5,i10)
 107  format(i2,i2,12i5)
 108  format(20i3)
 120  format(i3,i3,10f5.0)
 121  format(i3,9x,12f4.0)
 201  format('Species: ',10x,a12,/,
     -'Number of boats(fleet size):        ',i2,/,
     -'Random seed number(boat selection): ', i10/,
     -'Number of iterations(boat selection): ',i5/
```

```
     -'Percent coverage:                          ',i3,'%'/
     -'Number of iterations(cruise selection): ',i5/
     -'Random seed number(cruise selection):   ',i10//)
 202  format('    Population    Samp  Mean Kill Rel-bias  C.V.',
     -'  Variance    MSE       SQRT'/
     - 'Trip  Day   Kill  Size   (YHAT)    *100%   *100%',
     -'   (YHAT)   (YHAT)     (MSE)'
     -/80('-')/)
 203  format(i3,2f7.0,f5.1,f10.2,2f8.2,2F10.1,f9.1)
 204  format(/80('-'))
 205  format(8f10.2)
C-----------------------------------------------------------------
C input output files set up....
C-----------------------------------------------------------------
      print *,'Enter input selected vessel data file name: '
      read(5,101)in1
      print *,'Enter Output report data file name: '
      read(5,101)out1
  22  continue
      print *,'Enter sample coverage percentage: '
      read(5,105)ncov
      print *,'Enter desired number of iterations for selecting
      cruises: '
      read(5,104)iter2
      print *,'Enter the seed for generating random numbers: '
      print *,'Choose large integer number 6 digits - 8 digits '
      read(5,104)nseed
      l=index(out1,' ')
      l=l-1
      if(l.eq.0)then
        print *,'length of input file name=0 '
        stop
      end if
      confer=95.0
      open(unit=1,file='boat',status='old',blank='zero')
      open(unit=2,file=in1,status='old',blank='zero')
      open(unit=3,file='samp12',status='old',blank='zero')
      open(unit=11,file=out1(1:l)//'1',status='new')
      open(unit=12,file=out1(1:l)//'2',status='new')
      open(unit=13,file=out1(1:l)//'3',status='new')
      open(unit=14,file=out1(1:l)//'4',status='new')
      open(unit=15,file=out1(1:l)//'5',status='new')
      open(unit=16,file=out1(1:l)//'6',status='new')
      open(unit=17,file=out1(1:l)//'7',status='new')
      open(unit=18,file=out1(1:l)//'8',status='new')
C-----------------------------------------------------------------
C  Calculates the fraction & integer values of 6 % coverages
C-----------------------------------------------------------------
      do 444 i=1,100
        c=float(i)
        do 444 j=1,6
          d=float(j)
          b=c*d/100
          npc(i,j)=ifix(b)
          pc(i,j)=b-npc(i,j)
```

```
  444 continue
      iseed=-iabs(nseed)
      r=ran1(iseed)
      reps=float(iter2)
      if(reps.gt.1.0)then
        ratio= (1./(reps -1.0))
      else if(reps.eq.1.0)then
        ratio=1.0
      else
        print *,'error in nreps : ',nreps
      end if
C-----------------------------------------------------------------
C read in BOAT data file
C-----------------------------------------------------------------
      do 98 j=1,33
      read(1,107,end=999)ven,numc(ven),(sortn(ven,i),crn(ven,i),
     -i=1,numc(ven))
  98  continue
      close(unit=1)
C-----------------------------------------------------------------
C read in yearly sample (cruise total) data and stored in array
C-----------------------------------------------------------------
      do 96 j=1,124
        read(3,121,end=999)n,xday(n),xset(n),(kill(i,n),i=1,8)
  96  continue
      close(unit=3)
C-----------------------------------------------------------------
C simulation starts, read & output headings
C-----------------------------------------------------------------
      read(2,106)nves,iter1,nseed1
C      write(19,106)nves,iter1,iter2
      do 499 isp=1,8
C        write(isp+10,101)char(27)//char(12)//char(13)
c        ncov=npct(ipct)
         write(isp+10,201)kvar(isp),nves,nseed1,
     -             iter1,ncov,iter2,nseed
         write(isp+10,202)
 499  continue
C-----------------------------------------------------------------
C  read in vessel numbers and their population statistics
C-----------------------------------------------------------------
      do 500 irp=1,iter1
        read(2,105,end=999)(nsel(i),i=1,nves)
        read(2,120,end=999)j,ntot,yday,yset,(ysum(i),i=1,8)
        xmean=yday/ntot
C-----------------------------------------------------------------
C  zero out all output registers
C-----------------------------------------------------------------
        do 407 i=1,8
          sums2(i)=0.
          rsums2(i)=0.
          sums4(i)=0.
          rsums4(i)=0.
  407   continue
        nsize=0
```

```
C-----------------------------------------------------------------
C  do iter2 iterations to pick cruises for each selected vessel
C-----------------------------------------------------------------
        do 305 i=1,iter2
          do 306 ii=1,124
            ipick(ii)=0
 306      continue
          do 307 j=1,nves
            ven=nsel(j)
            noc=numc(ven)
            p=ran1(1)
C-----------------------------------------------------------------
C  decide the sample size for each vessel at P%
C-----------------------------------------------------------------
            if(p.lt.pc(ncov,noc))then
              nsamp=npc(ncov,noc)+1
            else
              nsamp=npc(ncov,noc)
            end if
C-----------------------------------------------------------------
C decide which cruise to be included in the sample
C-----------------------------------------------------------------
            ni=0
            do 308 jj=1,noc
              p=ran1(1)
              ps1=float(nsamp-ni)/float(noc-jj+1)
              if(p.le.ps1)then
                m=sortn(ven,jj)
C                                   m is the coded boat# (1-124)
                ipick(m)=1
                no(m)=no(m)+1
                if(ni.ge.noc)goto 309
                ni=ni+1
              end if
  308       continue
  309       continue
  307     continue
C-----------------------------------------------------------------
C  Store all statistics for all selected cruises of one group
C-----------------------------------------------------------------
          ifound=0
          do 400 ip=1,124
            if(ipick(ip).eq.1)then
              ifound=ifound+1
              dfound(ifound)=xday(ip)
              do 405 isp=1,8
                kfound(ifound,isp)=kill(isp,ip)
  405         continue
            end if
  400     continue
          if(ifound.eq.0)then
            print *,'Error in sample size, ifound=0'
          else
            nsize=nsize+ifound
          end if
```

```
C          write(19,100)(ipick(ij),ij=1,124)
C-----------------------------------------------------------------
C call subroutine to compute the total estimates
C-----------------------------------------------------------------
          do 439 isp=1,8
            temp(isp)=0
            if(ysum(isp).ne.0.)then
              call smprr(0,ifound,dfound,kfound(1,isp),
     -        ntot,0,xmean,coef,confer,stat)
            end if
            st4=sqrt(stat(4))
            sums2(isp)=sums2(isp) + stat(2)
            rsums2(isp)=rsums2(isp) + stat(2)**2
            sums4(isp)=sums4(isp) +  st4
            rsums4(isp)=rsums4(isp) + st4**2
            temp(isp)=stat(2)
  439     continue
C          write(19,205)(temp(isp),isp=1,8)
  305   continue
C-----------------------------------------------------------------
C calculate reporting statistics & clear register
C-----------------------------------------------------------------
        do 252  isp=1,8
          ymean=0.
          vhat=0.
          ybias=0.
          rybias=0.
          mse=0.
          smse=0.
          cv1=-99.99
          if(ysum(isp).ne.0.)then
            ymean=sums2(isp)/reps
            vhat=ratio*(rsums2(isp)- sums2(isp)**2/reps)
            ybias=ymean- ysum(isp)
            rybias=100.0 * ybias / ysum(isp)
            mse=vhat+ybias**2
            smse=sqrt(mse)
            cv1=(smse/ysum(isp))*100.0
          end if
C-----------------------------------------------------------------
C  write statistics for one group of vessel (average of iter2)
C-----------------------------------------------------------------
          size=float(nsize)/float(iter2)
          write(isp+10,203)ntot,yday,ysum(isp),size,ymean
     -    ,rybias,cv1,vhat,mse,smse
          vvhat(isp)=vvhat(isp)+vhat
          mmse(isp)=mmse(isp)+mse
          yysum(isp)=yysum(isp)+ysum(isp)
          yymean(isp)=yymean(isp)+ymean
          rrybias(isp)=rrybias(isp)+abs(rybias)
          ccv1(isp)=ccv1(isp)+cv1
          ssmse(isp)=ssmse(isp)+smse
  252   continue
        nntot=nntot+ntot
        yyday=yyday+yday
```

```
        ssize=ssize+size
  500 continue
C-----------------------------------------------------------------
C  Write the grand averages for iter1 iterations
C-----------------------------------------------------------------
      nntot=nntot/iter1
      yyday=yyday/iter1
      ssize=ssize/iter1
      do 501 isp=1,8
        yymean(isp)=yymean(isp)/iter1
        rrybias(isp)=rrybias(isp)/iter1
        ccv1(isp)=ccv1(isp)/iter1
        yysum(isp)=yysum(isp)/iter1
        mmse(isp)=mmse(isp)/iter1
        ssmse(isp)=ssmse(isp)/iter1
        vvhat(isp)=vvhat(isp)/iter1
        write(isp+10,204)
        write(isp+10,203)nntot,yyday,yysum(isp),ssize,yymean(isp)

     - ,rrybias(isp),ccv1(isp),vvhat(isp),mmse(isp),ssmse(isp)
  501  continue
       GO TO 1000
  999  CONTINUE
         PRINT *,'SIMULATION STOPS DUE TO INPUT READ ERROR'
 1000  CONTINUE
       stop
       end
```

```
C*****************************************************************
C
C    PROGRAM: PREKIL.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     1.  To select randomly P% of cruises.
C                 2.  To output selected cruise numbers.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        SEPTEMBER 20, 1988
C
C    DESCRIPTION: (sampling method)
C
C    1.   Each cruise number is coded in such a way that number 1
C         is the first trip that departed during the year, number
C         2 is the second trip,...,number 124 is the last trip.
C
C    2.   The program calculates the number of cruises to be
c         selected for each month at the specified % coverage.
c
c    3.   It then goes through all cruises made during that month
c         and includes the cruise in the sample if
c
c                 Ui <=  ( n - ni ) / N - i + 1
c
c         where Ui is the random number generated from U(0,1), ni
c         is the number of cruises selected prior to the
c         encounter of the ith cruise, and N is the total number
c         of cruise made in a month.
c
C    4.   It proceeds with this process from January to December
c         and repeats the process for a user specified number
c         of iterations.
c
c    5.   There will be 124 columns of 1's or 0's written onto a
c         disk record.  The first column represents cruise number
c         1, second column cruise number 2 and so on.  A '1' in
c         the ith column indicates the ith cruise is being
c         selected.
C
C    6.   When p% of the sample size is not an integer, the
c         sample size is determined by an equal probability
c         method.  If the random number generated is < the
c         fractional part of the sample size, the greater
c         integer is taken; otherwise the smaller integer is
```

```
c         taken as the sample size.
C
C    INPUT:       UNIT 3  - MOSUMC
C
C    OUTPUT:      UNIT 1  - User-supplied-file name (V%)
C
C    SUBROUTINES: RAN1.FOR - To generate uniformly distributed
C                            U(0,1) random numbers.
C
C    TO COMPILE:  C:\>RMFORT PREKIL
C
C    TO LINK:     C:\>PLINK86 FI PREKIL,RAN1
C
C    TO EXECUTE:  C:\>PREKIL
c
c    Enter output selected cruise data file name:
c    Enter the value of sample coverage percentages:
c    Enter the seed for generating random numbers:
c    Enter the number of iterations to be performed:
C*****************************************************************
      program prekil
      dimension no(124),ntot(0:12),samp(0:12),spp(12),new(0:12)
     -          ,ipick(125)
      CHARACTER*7 in1,out1,out2
c----------------------------------------------------------------
c format statements
C----------------------------------------------------------------
 100  format(124i1)
 101  format(a)
 102  format(f5.1)
 103  format(i4)
 104  format(i8)
 106  format(i3,i8,i4,i10)
 107  format(i2,i3)
C----------------------------------------------------------------
c input output file set up....
C----------------------------------------------------------------
c     call link("read5,unit5=tty,print6,unit6=tty//")     ! CRAY
      print *,'Enter output selected cruise data file name: '
      read(5,101)out1
      print *,'Enter the value of sample coverage percentage: '
     -'(format i3)'
      read(5,103)ncov
      print *,'Enter the seed for generating random numbers: '
      print *,'Choose large integer number 6 digits - 8 digits '
      read(5,104)nseed
      print *,'Enter the number of iterations to be performed: '
      read(5,104)nreps
      confer=95.0
      open(unit=3,file='MOSUMC',status='old',blank='zero')
      open(unit=1,file=out1,status='new')
c     svseed=float(nseed)                          ! CRAY
      pcnt=float(ncov)
      iseed=-iabs(nseed)
      r=ran1(iseed)
```

```
C-----------------------------------------------------------------
c  read in population statistics
C-----------------------------------------------------------------
      ntot(0)=0
      do 98 i=1,12
        read(3,107,end=98)m,ntot(m)
  98  continue
      close(unit=3)
C-----------------------------------------------------------------
c  calculate the total number of cruises started in each month
C-----------------------------------------------------------------
      new(1)=ntot(1)
      do 302 i=2,12
        new(i)=ntot(i) - ntot(i-1)
 302  continue
C-----------------------------------------------------------------
c  total # cruises to be sampled for each month at pcnt%
C-----------------------------------------------------------------
      do 300 i=1,12
       samp(i)=new(i) * pcnt * 0.01
 300  continue
c     call ranset(svseed)                                !CRAY
C-----------------------------------------------------------------
c simulation starts
C-----------------------------------------------------------------
      write(1,106)ncov,nseed,nreps
      do 50 irp=1,nreps
      do 303 i=1,124
        ipick(i)=0
 303  continue
      do 304 m=1,12
        ni=0
C-----------------------------------------------------------------
c  Actual # of cruises to be selected for each month for pcnt%
C-----------------------------------------------------------------
        nosamp=ifix(samp(m))
        def=samp(m)-nosamp
        if(def.eq.0.)then
          nsamp=nosamp
        else
c         p=ranf()                                        ! CRAY
          p=ran1(1)
          if(p.lt.def)then
            nsamp=nosamp+1
          else
            nsamp=nosamp
          end if
        end if
        spp(m)=spp(m)+nsamp
C-----------------------------------------------------------------
c  decide which cruise to be included in the sample
C-----------------------------------------------------------------
        do 305 i=1,new(m)
c         p=ranf()                                        ! CRAY
          p=ran1(1)
```

```
          ps1=float(nsamp-ni)/float(new(m)-i+1)
          if(p.le.ps1)then
            ii=i+ntot(m-1)
            ipick(ii)=1
            ni=ni+1
          end if
 305    continue
 304  continue
C-------------------------------------------------------------------
c  output indicators (1) for cruises have been selected
C-------------------------------------------------------------------
      write(1,100)(ipick(i),i=1,124)
  50  continue
      stop
      end
```

```
C*****************************************************************
C
C    PROGRAM: PREKIL2.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     1.  To select randomly 50% of cruises departing
c                    in each month with the "non-back-to-back"
c                    method.
c                2.  To output selected cruise numbers.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        FEBRUARY 25, 1989
C
C    DESCRIPTION: (sampling method)
C
c    1.   The program sequentially goes through boats 1 - N and
c         generates a number Ui from uniform (0,1).  It includes
c         the ith boat for inclusion in the sample if Ui <= ( n -
c         ni ) / N - i + 1
c
c         where ni is the number of boats selected prior to the
c         encounter of the ith boat, and n is the sample size.
c
c    2.   It selects all odd numbered cruises made by these
c         selected vessels and all even numbered cruises made
c         by vessels that were not selected.
C
c    3.   It outputs selected cruises for subsequent calculation.
c
c
C    INPUT:       UNIT 3  - MOSUMC
C
C    OUTPUT:      UNIT 1  - User-supplied-file name (V%)
C
C    SUBROUTINES: RAN1.FOR - To generate U(0,1) random numbers.
C
c    TO COMPILE:   C:\>RMFORT PREKIL2
C
C    TO LINK:     C:\>PLINK86 FI PREKIL2,RAN1
C
C    TO EXECUTE:  C:\>PREKIL2
C
c    Enter input selected vessel data file name:
c    Enter output file name for selected cruises:
c    Enter the seed for generating random numbers:
```

```
c    Enter the desired number of iterations:
C*****************************************************************
      PROGRAM PREKIL2
      dimension nsel(33),no(124),numc(33),nov(33),ysum(10)
      integer ven,sortn(33,6),days(124),crn,ipick(124)
      CHARACTER*7 in1,out1,out2
C-----------------------------------------------------------------
c format statements
 101  format(a)
 102  format(124i1)
 103  format(i4)
 104  format(i8)
 105  format(33i3)
 106  format(i3,i8,i4,i10)
 107  format(i2,i2,12i5)
 112  format(2i5,2x,i8)
 120  format(2i3,12f5.0)
C-----------------------------------------------------------------
c input output file set up....
C-----------------------------------------------------------------
      print *,'Enter input selected vessel data file name: '
      read(5,101)in1
      print *,'Enter output file name for selected cruises:'
      read(5,101)out1
      print *,'Enter the seed for generating random numbers: '
      print *,'Choose large integer number 6 - 8 digits : '
      read(5,104)nseed
      print *,'Enter the desired number of iterations:'
      read(5,103)iter2
      open(unit=1,file='boat',status='old',blank='zero')
      open(unit=2,file=in1,status='old',blank='zero')
      open(unit=3,file=out1,status='new')
C      svseed=float(nseed)
      iseed=-iabs(nseed)
      print *,iseed
      r=ran1(iseed)
      print *,iseed
      ncov=50
C-----------------------------------------------------------------
c read in vessel & cruise information data file.
C-----------------------------------------------------------------
      do 98 j=1,33
      read(1,107,end=999)ven,numc(ven),(sortn(ven,i),crn,
     -i=1,numc(ven))
  98  continue
      close(unit=1)
C      call ranset(svseed)
C-----------------------------------------------------------------
c simulation starts, read & output headings
C-----------------------------------------------------------------
      read(2,112)nves,iter1,lseed
      write(3,106)ncov,nseed,iter2,lseed
C-----------------------------------------------------------------
c  read in vessel numbers and their population statistics
C-----------------------------------------------------------------
```

```
      do 500 irp=1,iter1
        read(2,105,end=999)(nsel(i),i=1,nves)
        read(2,120,end=999)j,ntot,yday,yset,(ysum(i),i=1,10)
        xmean=yday/ntot
C-----------------------------------------------------------------
c  do iter2 iterations
C-----------------------------------------------------------------
        do 305 it=1,iter2
          do 306 i=1,124
            ipick(i)=0
 306      continue
C-----------------------------------------------------------------
c  decide the total sample size at 50% of 33 boats
C-----------------------------------------------------------------
          nsize=nves/2
          if(nsize*2.ne.nves)then
            p=ran1(1)
            if(p.le..50)then
              nsize=nsize+1
            end if
          end if
C-----------------------------------------------------------------
c  decide whether to include jth vessel in sample
C-----------------------------------------------------------------
          ni=0
          do 307 j=1,nves
            p=ran1(1)
            ps1=float(nsize-ni)/float(nves-j+1)
            if(p.le.ps1)then
C-----------------------------------------------------------------
c  Take the odd numbered cruises for this vessel
C-----------------------------------------------------------------
              ni=ni+1
              do 404 jj=1,numc(j),2
                m=sortn(j,jj)
                no(m)=no(m)+1
                ipick(m)=1
  404         continue
            else
C-----------------------------------------------------------------
c  Take the even numbered cruises for this vessel
C-----------------------------------------------------------------
            do 405 jj=2,numc(j),2
              m=sortn(j,jj)
              ipick(m)=1
              no(m)=no(m)+1
  405       continue
            end if
  307     continue
          write(3,102)(ipick(i),i=1,124)
  305   continue
  500 continue
  999 print *,'simulation stops'
      stop
      end
c-----------------------------------------------------------------
```

```
C*****************************************************************
C
C    PROGRAM: KILALL.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     1.  To compute monthly cumulative mortality
C                     estimates.
C                 2.  To report simulation results.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        OCTOBER 30, 1988
C
C
C    DESCRIPTION:
C
C    1.   File 1 contains monthly cumulative kill statistics
C         arranged in ascending order by their month and cruise
C         numbers.  There are a total of 901 records.
C
C    2.   File 2 contains cumulative monthly population
C         statistics.  There are a total of 12 records.
C
C    3.   File 3 contains the selected cruise numbers output
C         by the 'PREKIL' or 'PREKIL2' programs.
C
c    4.   The program reads in all data from files 1 and 2.  It
c         then reads in one record from file 3 and computes the
c         monthly cumulative kill estimates and their associated
c         values for the eight dolphin species/stock categories.
c
C    REVISIONS:   NONE
C
C    INPUT:       UNIT 1  - SAMPDAT
C                 UNIT 2  - MOSUMC
C                 UNIT 4  - CRU%
C
C    OUTPUT:      UNIT 3  - RPT%
C
C    SUBROUTINES: SMPRR
C
C    TO COMPILE:    C:\>RMFORT KILALL            (IBM)
C
C    TO LINK:       C:\>PLINK86 FI KILALL,SMPRR  (IBM)
C
c    TO EXECUTE:    C:\>KILALL
```

```
c    Enter input sample data file name:
c    Enter input population data file name:
C    Enter input selected cruise data file name:
C    Enter output report file name:
C    Choose one method of estimation
C      1 = Kill per day.
c      2 = Kill per set.
c      3 = Kill per ton.
c    (If your answer is 3, more choices follow:)
c    Which tonnage to choose for the estimation?
c      1 = total tuna tonnage.
c      2 = total yellowfin tonnage.
c
C*****************************************************************
      program kilall
      dimension ntot(0:12),yday(12),ysum(10,12)
     -         ,xmean(12),samp(12),yset(12),stat(20)
     -         ,ipick(124)
      real kill(10,124,12),days(124,12),kfound(124,10,12)
     -         ,dfound(124,12),sfound(124,12),xsets(124,12)
      real nopc(10,12),sums2(10,12),sums4(10,12),sumsl(10,12)
     -         ,rsums2(10,12),rsums4(10,12)
      real mse,meanse,nopcpcnt
      CHARACTER*7 in1,in2,in4,out3
      character*3 mon(12),pvar(3)
      character*12 kvar(10)
C-----------------------------------------------------------------
c  define label values
C-----------------------------------------------------------------
      data mon/'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug',
     -        'Sep','Oct','Nov','Dec'/
      data pvar/'Day','Set','Ton'/
      data kvar/'Total kill  ','Offshor spot','Estern spin ',
     -        'White  spin ','  Unknown   ','Comm dolphin',
     -        'Striped kill','Other kill  ','tot tuna ton',
     -        'tot Y.F. ton'/
C-----------------------------------------------------------------
c format statements
C-----------------------------------------------------------------
 101  format(a)
 102  format(f5.1)
 103  format(i5)
 105  format(i3,2x,i2,5x,12f4.0)
 106  format(i2,f6.0,2f5.0,10f6.0)
 107  format(i2,i3,2f4.0,f5.0,7f4.0,2f5.0)
 110  format(124i1)
 112  format(i3,i8,i4)
 400  format(10X,'SIMULATED MONTHLY CUMULATIVE ESTIMATES OF',
     -' DOLPHIN MORTALITY '/
     -20x,' BASED ON UNSTRATIFIED RATIO ESTIMATES'////
     1' No. of Independent Samples: ',i4/
     2' Random number seed value  : ',f10.0/
     3' Confidence Intervals      : ',f5.1,'%')
 401  format(10X,'SIMULATED MONTHLY CUMULATIVE ESTIMATES OF',
     -' DOLPHIN MORTALITY '/
```

```
     -20x,' BASED ON UNSTRATIFIED BOOTSTRAP RATIO ESTIMATES'////
     1' No. of Independent Samples: ',i4/
     2' No. of Bootstrap Samples  : ',i4/
     3' Random number seed value  : ',f10.0/
     4' Confidence Intervals      : ',f5.1,'%')
 403  format(21x,(15(1h-),3X))
 404  format(//29x,'           P o p u l a t i o n'/
     -' Month   Species/Estimator',12x,'Trips',4x,A3,'s    kill'/
     -70(1h-)/
     -2X,A3,5X,A12,'/',A3,12X,i5,3X,F6.0,3X,F7.0//)
 405  format(/'    PERCENT COVERAGE ',4x,6(f4.0,'%',12X))
 406  format(4x,'SAMPLE SIZE',6x,6(3x,f12.2,3x))
 407  format(4X,'MEAN (YHAT)',6X,6(3X,F12.2,3X))
 408  format(4X,'BIAS (YHAT)',6X,6(3X,F12.2,3X))
 409  format(4X,'REL BIAS(YHAT)*100%',6('(',F12.2,')',4X,:))
 410  format(4X,'V (YHAT)',9X,6(E15.8,3X))
 411  format(4X,'             ',3X,6('(',E15.8,')',1x,:))
 412  format(4X,'MSE(YHAT)',8X,6(E15.8,3X))
 413  format(4X,'        ',8X,6('(',E15.8,')',1X,:))
 414  format(4X,'CV(YHAT)*100%',4X,6(3X,F12.2,3X))
 415  format(4x,'%CI 1 CONT P.KILL',6(3X,F12.2,3X))
 416  format(4X,'AVE. LEN. CI.(1)',1X,6(3X,F12.2,3X))
 420  format(4x,'%CI 2 CONT P.KILL',6(3X,F12.2,3X))
 421  format(4X,'AVE. LEN. CI.(2)',1X,6(3X,F12.2,3X))
 417  format(4X,'MEAN(SEYHAT)',5X,6(3X,F12.2,3X))
 418  format(4X,'S.D.(SEHYAT)',5X,6(E15.8,3X))
 419  format(4X,'CV(SEYHAT)*100%',2X,6(E15.8,3X)/)
C      call link("read5,unit5=tty,print6,unit6=tty//")
C-----------------------------------------------------------------
c input output file set up....
C-----------------------------------------------------------------
      print *,'Enter input sample data file name: (sampdat)'
      read(5,101)in1
      print *,'Enter input population data file name: (mosumc)'
      read(5,101)in2
      print *,'Enter input selected cruise data file name: '
      print *,'(output from prekil program)'
      read(5,101)in4
      print *,'Enter output report file name: '
      read(5,101)out3
      open(unit=1,file=in1,status='old',blank='zero')
      open(unit=2,file=in2,status='old',blank='zero')
      open(unit=3,file=out3,status='new')
      open(unit=4,file=in4,status='old')
      read(4,112)ncov,nseed,nreps
      pcnt=float(ncov)
      svseed=float(nseed)
c 4   print *,'Enter desired percentage of confidence intervals '
c    -,' format f5.1):  '
c     read(5,*)confer
c     if(confer.gt.100.0.or.confer.lt.0.00)go to 4
c     ik=1
      confer=95.0
      reps=float(nreps)
  5   print *,'Choose one method of estimation: '
```

```
      print *,' 1 = kill per day '
      print *,' 2 = kill per set '
      print *,' 3 = kill per ton '
      print *,': '
      read(5,*)ik
      if(ik.gt.3.or.ik.lt.1)go to 5
  6   continue
      if(ik.eq.3)then
        print *,'Which tonnage to choose for the estimation? '
        print *,' 1 = total tuna tonnage '
        print *,' 2 = total yellowfin tonnage '
        read(5,*)iton
        if(iton.gt.2.or.iton.lt.1)go to 6
      end if
      print *,'All the following estimates will be calculated '
      print *,' 1 = total kill              5 = unknown spin kill'
      print *,' 2 = offshore spotted        6 = common dolphin'
      print *,' 3 = white spinner           7 = striped dolphin'
      print *,' 4 = Eastern Spinner         8 = other dolphin'
      print *,'Program updated Nov 1, 1988 for IBM-PC is running'
c-----------------------------------------------------------------
c.................................read population data(a total of
c                                  12 records , one for each month)
      ntot(0)=0
      do 98 j=1,12
        read(2,107,end=97)m,ntot(m),yday(m),yset(m),
     -  (ysum(i,m),i=1,10)
        tcru=float(ntot(m))
        if(ik.eq.1)then
          xmean(m)=yday(m)/tcru
        else if(ik.eq.2)then
          xmean(m)=yset(m)/tcru
        else
          id=8+iton
          xmean(m)=ysum(id,m)/tcru
        end if
  98  continue
  97  close(unit=2)
c-----------------------------------------------------------------
c.............................read all input sample data (a total
c                              of 901 records for 1987 data)
      do 99 im=1,901
        read(1,105,end=96)j,m,days(j,m),xsets(j,m),
     -  (kill(i,j,m),i=1,10)
  99  continue
  96  close(unit=1)
c-----------------------------------------------------------------
c.............................simulation starts
      do 50 irp=1,nreps
        print *,'repetition= ',irp
c.........................Unit 4 reads in one record which tells
c                         which cruises are being selected
C                         throughout the year.
c
        read(4,110)(ipick(i),i=1,124)
```

```
        ifound=0
c.........................Store statistics incurred by selected
C                           cruise for later computation
        do 40 m=1,12
          do 41 ii= ntot(m-1)+1, ntot(m)
            if(ipick(ii).eq.1)then
              ifound=ifound+1
c
              do 42 mo=m,12
                dfound(ifound,mo)=days(ii,mo)
                sfound(ifound,mo)=xsets(ii,mo)
                do 43 isp=1,10
                  kfound(ifound,isp,mo)=kill(isp,ii,mo)
   43           continue
   42         continue
            end if
   41     continue
c.........................add sample sizes from each iteration
          if(ifound.eq.0)then
            stat(1)=0.
            stat(2)=0.
            stat(4)=0.
            stat(7)=0.
            stat(8)=0.
            print *,'Error in sample size, ifound=0 at irp= ',irp
          else
            samp(m)=samp(m)+ifound
          end if
          do 39 isp=1,8
c.........................When population total is 0 skip.
c                           When sampled total is 0, the self-
c                           written subroutine SMPRR will return
c                           with 0 values.
            if(ysum(isp,m).ne.0.)then
            if(ik.eq.1)then
              call smprr(0,ifound,dfound(1,m),kfound(1,isp,m),
     -        ntot(m),0,xmean(m),coef,confer,stat)
            else if(ik.eq.2)then
              call smprr(0,ifound,sfound(1,m),kfound(1,isp,m),
     -        ntot(m),0,xmean(m),coef,confer,stat)
            else if(ik.eq.3)then
              call smprr(0,ifound,kfound(1,id,m),kfound(1,isp,m),
     -        ntot(m),0,xmean(m),coef,confer,stat)
            else
              print *,'error in logic, ik= ',ik
            end if
c
c.........................cumulate estimates for final report
c
              st4=sqrt(stat(4))
              sums2(isp,m)=sums2(isp,m) + stat(2)
              rsums2(isp,m)=rsums2(isp,m) + stat(2)**2
              sums4(isp,m)=sums4(isp,m) +  st4
              rsums4(isp,m)=rsums4(isp,m) + st4**2
              d=stat(8)-stat(7)
```

```
              sumsl(isp,m)=sumsl(isp,m) + d
              if(ysum(isp,m).ge.stat(7).and.ysum(isp,m).le
     -        .stat(8))then
                nopc(isp,m)=nopc(isp,m) + 1.
              end if
            end if
   39     continue
   40   continue
   50 continue
c
c.............................calculating of reporting statistics
c
      if(reps.gt.1.0)then
        ratio= (1./(reps -1.0))
      else if(reps.eq.1.0)then
        ratio=1.0
      else
        print *,'error in nreps : ',nreps
      end if
      do 251 m=1,12
c..................................take the average sample size
c
        samp(m)=samp(m)/reps
        do 252  isp=1,8
c.....................................clear all register
c
          ymean=0.
          vhat=0.
          svhat=0.
          ybias=0.
          rybias=0.
          mse=0.
          smse=0.
          cv1=-99.99
          meanse=0.
          sdevse=0.
          nopcpcnt=100.0
          avelen=0.
          cv2=-99.99
c
          if(ysum(isp,m).ne.0.)then
            ymean=sums2(isp,m)/reps
            vhat=ratio*(rsums2(isp,m)- sums2(isp,m)**2/reps)
            svhat=sqrt(vhat)
            ybias=ymean- ysum(isp,m)
            rybias=100.0 * ybias / ysum(isp,m)
            mse=vhat+ybias**2
            smse=sqrt(mse)
            cv1=(smse/ysum(isp,m))*100.0
            meanse=sums4(isp,m)/reps
            sdevse=ratio * (rsums4(isp,m)-sums4(isp,m)**2/reps)
            sdevse=sqrt(sdevse)
            nopcpcnt=nopc(isp,m)/reps*100.0
            avelen=sumsl(isp,m)/reps
            if(meanse.eq.0.0)then
```

```
              cv2=-99.99
            else
              cv2=(sdevse/meanse)*100.0
            end if
          end if
C.....................................writes formfeed
c         call formfeed(3)
          write(3,101)char(27)//char(12)//char(13)
          write(3,400)nreps,svseed,confer
          if(ik.eq.1)then
          write(3,404)pvar(ik),mon(m),kvar(isp),pvar(ik),ntot(m)
     -      ,yday(m),ysum(isp,m)
          else if(ik.eq.2)then
          write(3,404)pvar(ik),mon(m),kvar(isp),pvar(ik),ntot(m)
     -      ,yset(m),ysum(isp,m)
          else if(ik.eq.3)then
          write(3,404)pvar(ik),mon(m),kvar(isp),pvar(ik),ntot(m)
     -      ,ysum(id,m),ysum(isp,m)
          else
            print *,'error in logic, ik= ',ik
          end if
c
          write(3,405)pcnt
          write(3,403)
          write(3,406)samp(m)
          write(3,407)ymean
          write(3,408)ybias
          write(3,409)rybias
          write(3,410)vhat
          write(3,411)svhat
          write(3,412)mse
          write(3,413)smse
          write(3,414)cv1
          write(3,415)nopcpcnt
          write(3,416)avelen
          write(3,417)meanse
          write(3,418)sdevse
          write(3,419)cv2
 252    continue
 251  continue
      close(unit=4)
      close(unit=3)
      stop
      end
```

```
C*****************************************************************
C
C    SUBPROGRAM: SMPRR.FOR
C
C*****************************************************************
C
C    SYSTEM:      DOLPHIN MORTALITY ESTIMATE SIMULATION
C
C    PURPOSE:     To compute statistics for inferences regarding
C                 the population total using ratio estimation
C                 method.
C
C    LANGUAGE:    RM-FORTRAN
C
C    PROGRAMMER:  CHRISTINA PERRIN
C                 U.S. DEPT. OF COMMERCE
C                 NATIONAL MARINE FISHERIES SERVICE
C                 SOUTHWEST FISHERIES CENTER, P.O. BOX 271
C                 LA JOLLA, CA. 92038
C
C    DATE:        OCTOBER 20, 1988
C
C
C    DESCRIPTION: This routine replaces the IMSL/STAT library
C                  routine: 'SMPRR'. All parameters used in
C                  this routine are the same as those used in the
C                  IMSL/STAT 'SMPRR' routine except with the
C                  following restrictions:
C
C              1.  The confidence level (confer) for a two-sided
C                  interval estimate is set to be 95.0%
C              2.  IDO is preset to 0.
C              3.  IOPT is present to 0.
C              4.  RCOEF is not used.
C              5.  Only STAT(2), STAT(4), STAT(7), STAT(8) are
c                  output.
C
C    REFERENCE:  Cochran, William G. (1977), Sampling Techniques,
C                3rd edition, John Wiley & Sons, New York.
C
C    INPUT ARGUMENTS:
C
C    IDO : PRESET TO 0 =This is the only invocation of smprr for
C          this data set, and all data are input at once.
C    NROW: The number of observations currently input in X and Y
C          vector.
C    X :   Containing the data for the auxiliary variable in the
C          random sample, e.g. days.
C    Y :   containing the data for the variable of interest in
C          the random sample, e.g. kill.
C    NTOT: Number of pairs of elements in the sampled population.
C          (e.g., number of cruises in the population)
C    IOPT: Preset to 0 = Ratio estimates is used for inference
C          about the population total.
C    XMEAN:Population mean of the auxiliary variable.
```

```
C          (e.g., total days / total cruises)
C     RCOEF:Not used here.
C     CONFER:Confidence level for two-sided interval estimate in%.
C
C     OUTPUT ARGUMENTS:
C
C     STAT(1) = estimate of the mean using ratio estimate method.
C     STAT(2) = estimate of the total.
C     STAT(4) = Variance estimate of the total estimate.
C     STAT(7) = Lower confidence limit for the total.
C     STAT(8) = Upper confidence limit for the total.
C
C     TO COMPILE:  C:\>RMFORT SMPRR
C
C     TO LINK:     C:\>PLINK86 FI CALLING-PROGRAM-NAME, SMPRR
C
C*****************************************************************
      subroutine smprr(ido,nrow,x,y,ntot,iopt,xmean,rcoef,confer
     -                 ,stat)
      dimension x(nrow),y(nrow),stat(20)
C
C-----------------------------------------------------------------
C clear all accumulators
C-----------------------------------------------------------------
C
      sx=0.
      sy=0.
      sxy=0.
      sx2=0.
      sy2=0.
      stat(2)=0.
      stat(4)=0.
      stat(7)=0.
      stat(8)=0.
C
C-----------------------------------------------------------------
C cumulate sums and sums of squares
C-----------------------------------------------------------------
C
      do 40 i=1,nrow
        sx=sx+x(i)
        sy=sy+y(i)
        sxy=sxy+x(i)*y(i)
        sx2=sx2+x(i)**2
        sy2=sy2+y(i)**2
  40  continue
C
C-----------------------------------------------------------------
C return to calling program if sample total =0
C-----------------------------------------------------------------
c
      row=float(nrow)
      if(sx.eq.0.and.sy.ne.0.)then
        print *,'inconsistent data, sx=0, sy>0'
        return
```

```
      end if
      if(sy.eq.0)then
        stat(1)=0.
        stat(2)=0.
        stat(4)=0.
        stat(7)=0.
        stat(8)=0.
C       print *,'0 kill , 0 return from sub smprr '
        return
      end if
C
C-----------------------------------------------------------------
C calculation using ratio estimate
C-----------------------------------------------------------------
C
      ratio=sy/sx
      stat(1)=ratio*xmean
      stat(2)=stat(1)*ntot
      sd=(sy2 + ratio**2*sx2 -2*ratio*sxy)/(row-1.0)
      p=(ntot**2/row)*(1.0 -  row/ntot)*sd
      stat(4)=p
C
C-----------------------------------------------------------------
C confidence level is set to be 95.0
C-----------------------------------------------------------------
C
      d=1.96 * sqrt(p)
      stat(7)=stat(2) - d
      stat(8)=stat(2) + d
      return
      end
C*****************************************************************
```